Conflicts between seals and fishing gear on Prince Edward Island

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ABSTRACT

Information on distribution, population trends, and fishing gear interactions of seals in Prince Edward Island was obtained from commercial fishers through a mail-out and telephone survey and by personal interviews. Survey responses were received from 281 fishers. Survey results and reports of animals necropsied at the Atlantic Veterinary College indicated that grey seals (*Halichoerus grypus*) are widely distributed in inshore waters of PEI, but that harbour seals (*Phoca vitulina*) are concentrated in the southeastern part of the province. Most (81.5%) respondents indicated that seal populations are increasing in their areas. Seal-gear interactions were reported in all fixed gear fisheries and in one mobile fishery (for bluefin tuna *Thunnus thynnus*). Based on respondent reports, seal-gear conflicts in 1997 cost the PEI fishing industry $6.2 million, which is 6.1% of the total landed value of commercial fisheries. However, this figure likely overestimates true losses by a substantial degree. In several fisheries for estuarine finfish, reported cost of repairing seal-damaged gear was greater than reported landed values, and catch losses attributed to seals were several times greater than reported landings. This suggests that respondents overstated losses. The bulk (90%) of estimated economic loss was due to diminished catches; the remainder was due to the time and dollar cost of gear repair. About half of total estimated loss occurred in the lobster (*Homarus americanus*) fishery, where seals were reported to damage trap entrances to gain access to bait. In gillnet fisheries for flatfish, herring (*Clupea harengus*), and mackerel (*Scomber scombrus*), seals were reported to steal gilled fish, make holes in nets, and scare fish away from nets. Reported losses were most severe in fisheries for smelts (*Osmerus mordax*) and silversides (*Menidia menidia*), where seals were reported to eat gilled fish, make holes in trap-nets allowing fish to escape, and scare fish away from the area. Seal-gear conflicts in the estuarine sector caused many fishers to move their gear or to shorten their fishing seasons. Seals, particularly grey seals, were reported to take baited hooks set for tuna and to steal chum used to attract tuna. There is an economic cost to mitigative measures and to fishers having given up certain fisheries due to excessive gear conflicts, but these costs are not addressed in this survey. Seal-induced losses in the lobster fishery can be reduced by putting bait inside bags, but effective mitigative measures have not been found for gillnets and trap-nets. An estimated 790 seals died in 1997 as a result of conflict with gear set by PEI fishers. Some of this mortality occurred during the tuna fishery in Nova Scotia waters. Stomachs of 11 harbour seals taken in smelt trap-nets in winter contained smelt, winter flounder (*Pseudopleuronectes americanus*), and tomcod (*Microgadus tomcod*). Seal-gear interactions on Prince Edward Island cause harm to both seals and the fishery, and detrimental effects are likely to increase if seal populations continue to rise.

RÉSUMÉ

Des renseignements sur la distribution et les variations d'abondance des populations de phoques et leurs interactions avec les engins de pêche à l'Île-du-Prince Édouard ont été obtenus par l'entremise d'un questionnaire et d'entrevues avec des pêcheurs commerciaux. Des réponses ont été reçues de 281 pêcheurs. Les résultats du sondage et les rapports des nécropsies effectuées au Collège vétérinaire de l'Atlantique suggèrent que les phoques gris (*Halichoerus grypus*) sont distribués dans les eaux côtières à travers toute la province, mais que les phoques communs (*Phoca vitulina*) sont concentrés dans sa partie sud-est. La plupart (81.5%) des pêcheurs qui ont répondu ont indiqué que les populations de phoques sont en voie d'augmentation dans leur région. Les interactions entre phoques et engins de pêche ont été rapportées dans toutes les formes de pêche par engins fixes et dans une pêche mobile (pour le thon rouge *Thunnus thynnus*). Selon les rapports des répondants, les conflits phoques-engins de pêche ont coûté $6.2 millions à l'industrie de la pêche de l'IPE en 1997, qui est 6.1% de la valeur des débarquements de la pêche commerciale. Pourtant, il est probable que ce chiffre surestime les vraies pertes par une marge substantielle. Dans plusieurs pêches pour les poissons estuariens, le coût rapporté des réparations des engins endommagés par les phoques était supérieur à la valeur rapportée des débarquements, et les pertes attribuées aux phoques étaient plusieurs fois plus importantes que les débarquements rapportés. La majorité (90%) des pertes économiques estimées était due aux réductions dans les prises; le restant était dû au coût en temps et en dollars des réparations des engins. A peu près la moitié des pertes estimées se trouvait dans l'industrie du homard (*Homarus americanus*), où on rapportait que les phoques endommageaient les entrés des cages pour accéder l'appât. Dans les pêches au filet maillant pour les poissons plat, le hareng (*Clupea harengus*) et le maquereau (*Scomber scombrus*), on rapportait que les phoques volaient les poissons pris dans le filet, faisaient les trous dans le filet, et effrayaient les poissons de sorte qu'ils quittaient l'endroit. Les pertes rapportées étaient les plus sévères dans les pêches à l'éperlan (*Osmerus mordax*) et à la capucette (*Menidia menidia*), où selon les répondants les phoques mangeaient les poissons pris dans les filets, faisaient les trous qui permettaient les poissons de s'échapper aux filets-trappes, et effrayaient les poissons qui quittaient les alentours de l'engin. Les conflits phoque-engin ont induit plusieurs pêcheurs de déplacer leurs engins ou de raccourcir leur saison de pêche. On rapportait que les phoques, surtout le phoque gris, prenaient les hameçons appâtés dans la pêche au thon

rouge, et volaient l'appât distribué sur l'eau pour attirer le thon. Il y a un coût économique des mesures préventives visant à réduire les pertes, et de l'abandon de la pêche par les pêcheurs qui subissaient des pertes excessives, mais ces coûts ne sont pas considères dans cette étude. Les pertes causées par les phoques dans la pêche au homard peuvent être réduites si les appâts sont placés dans des sacs. Par contre, aucune méthode préventive efficace dans la pêche avec filets maillants et filets-trappes ne semble disponible. Nous estimons que 790 phoques sont morts en 1997 à la suite d'interactions avec des engins placés par les pêcheurs de l'IPE. Une partie de cette mortalité est survenue dans les eaux de la Nouvelle-Écosse durant la pêche au thon. Les estomacs de 11 phoques communs provenant des filets-trappes à l'éperlan durant l'hiver contenaient des éperlans, des plies rouges (*Pseudopleuronectes americanus*) et des poulamons (*Microgadus tomcod*). Les interactions entre les phoques et les engins de pêche à l'Île-du-Prince-Édouard ont des effets néfastes pour les phoques et pour la pêche commerciale et ces effets vont probablement s'intensifier si les populations de phoques continuent d'augmenter.

INTRODUCTION

Seals typically feed on a diverse assortment of marine prey (Boulva and McLaren 1979, Benoit and Bowen 1990a, Hammill and Stenson 2000). Their use of fish for food, and their presence on inshore and offshore fishing grounds, lead to frequent interactions with commercial fisheries. These interactions include real or potential competition for the same prey, transmission of parasites to commercially valuable species, and gear interference. Interactions with fishing gear may involve damage to captured fish, damage to gear, and reduced catch rates due to scaring of target species (Harwood 1984, 1992; Harwood and Greenwood 1985, Smith 1995). Studies in Nova Scotia suggest that such interactions have substantial economic cost to the fishery (Mansfield and Beck 1977, Zwanenburg and Beck 1981, Farmer and Billard 1984). Gear interactions may also lead to seal mortality due to entanglements and drownings.

Prince Edward Island is Canada's leading fishing province in terms of fishery landed value as a percent of Gross Domestic Product (Cairns 1995). Lobsters (*Homarus americanus*) account for the bulk of landed value, and fisheries for this and most other species are prosecuted with stationary gear. Concerns about seal interactions with the PEI commercial fishery have been raised for many years. In 1986, the PEI Minister of Fisheries characterized gear damage by grey and harbour seals as a major economic consideration (Northridge 1986). More recently, seal - fisheries interactions have become a recurring theme in the PEI fishing industry, with many fishers reporting substantial economic losses due to seal interactions (D. Strongman, PEI Fishermen's Association, pers. comm.). Despite the widespread perception that seals cause significant losses, there is no documented information on seal-fishery interactions on PEI.

PEI's seal fauna includes four species. The harbour seal (*Phoca vitulina*) and the grey seal (*Halichoerus grypus*) are present year round, while the hooded seal (*Cystophora cristata*) and the harp seal (*Phoca groenlandica*) are winter visitors. A fifth pinniped, the walrus (*Odobenus rosmarus*), was numerous at the time of European contact but was extirpated at the beginning of the 1800s (Hogan 1986).

Harbour seals are the smallest species, with adults weighing up to 100 kg. They breed in the spring and generally occupy the same areas year round (Boulva and McLaren 1979). Grey seals are larger than harbour seals, reaching a maximum weight of 300 kg. There are two main components of the eastern Canadian grey seal population, one in the Gulf of St. Lawrence, and the other based primarily on the Scotian Shelf (Stobo and Zwanenburg 1990, Lavigueur and Hammill 1993). Both components pup in winter. Gulf grey seals give birth in central and eastern Northumberland Strait, usually on ice. After pupping, the herd disperses throughout the Gulf, and some individuals move into the open Atlantic. Some grey seals remain in the vicinity of Prince Edward Island and northern Nova Scotia. Harp and hooded seals are found in winter and early spring in the Gulf of St. Lawrence. Normally whelping occurs well north of PEI, but in some years poor ice conditions force the herds close to the PEI coastline. Populations of harbour, grey, harp, and hooded seals have increased in eastern Canada since the 1970s (Hammill and Stenson 2000), although harp numbers appear to have leveled off after 1996 (Stenson et al. 1999).

This paper investigates the nature, frequency, and economic cost of seal interactions with fishing gear on PEI. The primary information source is a survey of randomly-selected fishers, supplemented by personal interviews and site visits. We also review mitigative measures that might reduce seal-gear conflicts, summarize information supplied by fishers on distributions and population trends of seals in PEI waters, and present preliminary stomach data on harbour seals taken in winter fisheries. The study was sponsored by the Prince Edward Island Fishermen's Association in collaboration with the PEI Department of Fisheries and Tourism, the Department of Fisheries and Oceans, and the Atlantic Veterinary College of the University of Prince Edward Island.

METHODS

Information on seal abundance, distribution, and gear interactions was solicited through a questionnaire mailed to Prince Edward Island commercial fishers on 8 December 1997. Names were selected as follows:

a) 1,000 names were randomly drawn from the list of fishers holding commercial licences in PEI waters.

b) Local fisheries officers were asked to name fishers who fish smelt (*Osmerus mordax*) and silverside (*Menidia menidia*) in their areas. The resulting list was considered to include most, but not all, fishers prosecuting these fisheries (a list of active smelt and silverside fishers could not be derived from licence lists because many fishers who hold licences for these species do not actually fish them).

c) Names of smelt and silverside fishers who were not already on the list of 1,000 randomly selected names were added to that list. Sixty-six fishers were added in this way.

d) Names of sixty-six fishers who fish bivalve shellfish only were removed from the list, to yield a final mail-out list of 1,000 names.

A reminder notice with a second questionnaire copy was mailed 5 January 1998 to fishers from the original sample whose completed survey had not been received.

Both the original and the reminder mail-outs were accompanied by business reply envelopes.

To control for response bias (respondents with a large stake in the issue may have a higher than average probability of returning questionnaires), 40 fishers who did not return their questionnaires were randomly chosen and contacted by telephone and asked the questions in the questionnaire.

The questionnaire (Appendix 1) asked respondents to identify the areas where they fished in 1997, to locate sites where they regularly saw seals, and to provide information on species identity, peak numbers, and local population trends (for smelt fishing, the season was identified as fall 1996/winter 1997). Respondents were asked to complete a table indicating the species they fished and the nature and extent of seal-induced losses in each fishery. The species and gear types listed on the chart excluded those which were thought to be unlikely to have seal interactions (e.g. mollusc fisheries, bottom trawl fisheries). Data are reported in six areas, representing the Gulf of St. Lawrence and Northumberland Strait shorelines of Prince Edward Island's three counties (Fig. 1).

Supplementary information on gear interactions was obtained through telephone and in-person interviews with 22 fishers whose questionnaires revealed a high incidence of interactions. During these interviews fishers were asked their opinions on the potential usefulness of mitigative measures that have been developed in other areas, and to outline any mitigative measures they thought might prove successful on Prince Edward Island. The nature of seal interactions with smelt gear was also investigated through visits to winter fishing operations.

Direct counts of seals were obtained from a helicopter survey of the coastline of southeastern PEI from Squaw Point to Montague at 8:30-9:30 on 3 June 1997.

Harbour seals for diet analysis were obtained in January and February 1998 from animals drowned in smelt fishing gear. Each stomach was cut at the pyloric and esophageal sphincters and removed. In the preliminary analysis reported here, stomachs were opened and prey were identified visually.

Fishers responding to questions on losses to marine mammals often supply numbers with an extended right-hand distribution, which greatly inflate means (Lien et al. 1994). To test for bias due to extreme reported values, means of peak reported seal numbers, catch losses and expenditures due to seal interactions, and number of seals dying per respondent were calculated from both raw data sets and from truncated data sets in which large values were excluded.

RESULTS

Questionnaire response rate

Ninety completed questionnaires were received from the first mailout. The second mailout (with the reminder notice) resulted in the return of an additional 191 completed surveys. In all, 281 completed questionnaires were received for a response rate of 28.1%. Forty fishers who did not return the questionnaire were chosen at random and telephoned to complete the questionnaire. All fishers contacted in this way provided information as requested. The total number of fishers from whom questionnaire information was obtained was 321 (32.1% of the original sample). Questionnaire data were obtained from fishers residing in all regions of the province (Table 1).

Distribution, numbers, and seasonal trends

Seventy-seven percent (246 of 321) of respondents marked locations of seals on the map provided in the questionnaire (Table 1). Harbour seals were reported by 67% of those who mentioned seal species. Grey, harp, and hooded seals were reported by 39.5%, 18.5%, and 4.3% of respondents who reported species.

Respondents who reported the presence of harbour seals indicated that seals were widely distributed around Prince Edward Island (Fig. 2). The largest concentrations of reports occurred in North Cape (15 reports), Seacow Pond (13 reports), Alberton (14 reports), and Murray Harbour (20 reports). The helicopter survey on 3 June 1997 revealed 183 harbour seals at Reynolds and Cherry Island in Murray Harbour, and several unidentified seals in Hillsborough Bay which may have been harbour seals (Fig. 3).

Fishers reported that harbour seals appear to be moving into areas of the North Shore where they had not been seen previously (e.g. some parts of Cascumpeque Bay). In winter, harbour seals were reported only from Summerside Harbour and West River, which are sites of major winter smelt fisheries (Cairns 1997), and from the Pinette River.

Respondents reported 20 harbour seal pupping sites on PEI (Fig. 4). Most sites were in Hillsborough Bay and vicinity (seven sites) and Kings County from Murray Harbour to Souris (eight sites). Sites were reported by one respondent only, except for Governors Island in Hillsborough Bay (two reports) and the Murray Islands in Murray Harbour (17 reports).

Respondents who mentioned the presence of grey seals also reported a widespread distribution of seals around the PEI coast (Fig. 5). The largest concentrations of sightings were at Seacow Pond (10 reports) and Murray Harbour (16 reports).

Grey seals were reported to be present year-round in Percival River and Cascumpeque Bay, both of which are sites of winter smelt fisheries (Cairns 1997).

Reports of seals by those mentioning presence of harp seals were sparsely distributed around PEI, and reports by those mentioning hooded seal presence were limited to the east and north sides of the province (Figs. 6 and 7).

Reports of the number of seals in respondents' areas during peak periods averaged 15,512, with a range of 1 to 1,000,000 (Table 1). Because of the presence of a few large values, the mean was much larger than the median (150). Peak numbers reported by respondents who did not report presence of harp and hooded seals showed a similar pattern (mean 13,252, range 1-1,000,000, median 100). Peak numbers calculated after excluding values greater than or equal to five times the median yielded a mean of 161, a range of one to 500, and a median of 100. Median values of peak reported numbers, calculated by this method, were highest in Prince North (200) and Kings South (200) and lowest in Queens North (20) and Queens South (36).

In all areas a majority of respondents (81.5% overall) reported that seal numbers were increasing (Table 1). A single respondent (from the Hillsborough River area) reported that seal numbers were decreasing (0.3%). The remaining respondents (18.1%) reported that seal numbers were staying about the same.

Monthly presence of seals was reported by 280 respondents (Table 1). Frequency of reported seal presence was highest from May to October, when presence was reported by 59.3-74.3% of respondents. Reported presence was lowest in January-March (11.8-17.9% of respondents reporting presence).

From 1989 to spring 1999, 79 seals from Prince Edward Island were necropsied at the Atlantic Veterinary College. These animals had been found dead or moribund on shore or inland by members of the public and reported to provincial environment officials, who submitted them to the AVC Diagnostic Laboratory. The vast majority of these animals had empty stomachs, and no information on diet was recorded. Carcasses included harbour, grey, and harp seals collected in all seasons, and hooded seals collected in all seasons except December-February (Tables 2 and 3). Grey seals were reported from all regions, and harp seals were reported from all regions except Kings South (Table 3, Fig. 8). Harbour seals were reported only from Kings South and Queens South. Both hooded seals of known origin were reported from Queens North.

Seal-gear interactions

The number of fisheries prosecuted by mail-out survey respondents totaled 560, of which 330 (58.9%) were reported to have seal-gear interactions (Table 4). Among phone survey respondents, 62 of 116 (53.4%) fisheries were reported to have seal-gear interactions. Interaction rates did not differ significantly between the survey types (t_s=1.06, P=0.29; test of equality of percentages, Sokal and Rohlf 1969); hence subsequent analysis are based on pooled mail-in and phone-out results.

Catch losses per fisher who reported interactions were calculated from raw data, and from a truncated data set which excluded values greater than the mean + 2SD of non-zero values (Table 5). The mean of raw catch losses exceeded the mean from the truncated distribution by 6.5%, and differences exceeded 5% in only three fisheries. This suggests that catch loss estimates were not inflated by extreme values (Lien et al. 1994). Consequently, provincial loss totals were estimated by means calculated from the full data set. Fishery losses due to seals in 1997 were estimated for PEI as the product of the proportion of respondents who reported seal interactions in each fishery, and the mean reported loss per respondent for that fishery (Table 6).

Lobster is fished on PEI with baited traps in depths to about 35 m. The fishery is effort limited through restrictions on season and number of traps. Seasons are ~7 August - ~ 9 October in Prince South and 1 May - 30 June elsewhere. Seal interactions with lobster gear were reported by 38.9% of respondents (Table 4). Interactions were reported in all regions except Queens North, where none of nine respondents reported interactions. Mean reported loss per fisher was 656 kg, most of which (401 kg) was attributed to seals stealing bait from traps (Table 5). According to comments given in the questionnaires and to fishers contacted for follow-up interviews, seals commonly break the trap doors or entrance rings to access the bait. Many fishers also felt that the presence of seals discouraged lobsters from entering the traps. Several respondents noted that seal interference with herring (*Clupea harengus*) nets caused problems in securing bait for the lobster fishery.

Estimated seal-induced losses to the lobster fishery totaled $3.2 million, or 4.3% of the landed value of that fishery in 1997.

Snow crabs (*Chionoecetes opilio*) are fished with baited traps in waters north and east of PEI in a spring season, with most catches occurring in May. Water depths are typically 35 m and greater. The fishery is limited by seasonal boat quotas, which are normally fully taken. Of three respondents who reported fishing snow crabs, one (33.3%) reported seal interactions in the form of

capturing a seal (species not given) in a snow crab trap (Tables 4-5). No estimates of catch loss were given.

Rock crabs (*Cancer irroratus*) are fished with baited traps in waters to about 35 m depth, during various seasons from late June to November. Most fishing occurs in the Northumberland Strait. Fishing in this area is limited by individual boat quotas. Most fishers in this area attain their quota. The fishery on the Gulf of St. Lawrence side of PEI is much smaller, and is effort limited.

In the rock crab fishery, eight of 19 (42.1%) of respondents reported seal interactions (Table 4). Losses per respondent totaled 1,036 kg, most of which (847 kg) was attributed to seals stealing bait or damaging gear (Table 5). Respondents indicated that seals broke into traps to steal bait in the same manner as in the lobster fishery. Total losses in 1997 were estimated as $15,607, or 1% of the landed value of the fishery (Table 6).

Species fished by gillnets on PEI include winter flounder (*Pseudopleuronectes americanus*) and other flatfish, herring, mackerel (*Scomber scombrus*), and smelt. Fishers reported that seals frequent areas where gillnets are set and tear fish from both sides, often leaving large holes in the net. Seals also become tangled and drown in these nets, resulting in gear damage and time lost to remove them.

Loosely set gillnets (tangle nets) are used to fish flatfish in varying seasons from May to October. The fishery is subject to individual and fleet quotas, which are fully taken in most years. About one half (10 of 19, 52.6%) of flatfish gillnetters reported seal interactions (Table 4). The primary source of losses was fish escaping through holes (454 kg of 624 kg lost per respondent) (Table 5). Total estimated cost of gear interactions was $70,107, or 31.3% of the landed value of the fishery (Table 6).

The herring fishery is prosecuted with surface-set gillnets in spring (primarily May) and with bottom-set gillnets in fall (mid August to mid-to-late September). The spring commercial fishery on spawning herring in western PEI is subject to a fleet quota, which is taken in most years. The spring fishery for lobster bait is subject to a daily boat quota which is taken by a small proportion of fishers. The fall commercial fishery on spawning herring is subject to a fleet quota, which has not been taken in recent years.

Most respondents who fished herring reported seal interactions (95 of 132, 72.0%;Table 4). Mean losses per respondent totaled 158 kg, which were distributed among fish escaping through holes inability to fish in areas of high seal risk, seals eating or damaging fish that were caught, and seals scaring fish away from nets (Table 5). One respondent from the Alberton area reported seeing groups of up to 20 grey seals feeding on live herring that had fallen from gillnets as they were being hauled in the spring fishery. Total estimated loss was $171,893, which is 6.1% of the fishery's landed value (Table 6).

Mackerel are fished with surface-set gillnets primarily in June-September. The fishery is subject to a fleet quota but landings have been much smaller than the quota in recent years. Sixty-three of 116 mackerel gillnetters reported seal interactions (53.4%, Table 4). Respondents reported mean losses of 5,957 kg due primarily to seals scaring fish away from nets and to inability to fish in areas of high seal risk (Table 5). Total estimated losses were $844,939, which is 36.4% of landed value (Table 6).

The smelt gillnet fishery is open from 1 October to the end of February, but most gillnetting effort occurs in the fall prior to ice formation (typically mid-December) (Cairns 1989, 1997). The fishery is effort limited through restrictions on season and gear. Nets are set in estuaries and bays.

Comments on the questionnaire and from interviewed fishers indicated that seals raiding smelt gillnets commonly leave nothing but heads in the net, and frequently make holes in the net while feeding on gilled fish. One gillnet fishing site was visited. On the day of the visit, the net was filled with partially eaten smelts and the total saleable catch was 4 kg. The fisher reported that daily catch had averaged 70 kg prior to the seals' arrival in the area. The fisher removed his nets from the water on that day.

The majority (86.1%) of smelt gillnetters who responded to the survey reported seal interactions, and the mean per-fisher loss was 3,876 kg (Tables 4 and 5). The major sources of reported losses were seals scaring fish away from gear (1,185 kg), seals eating fish in nets (1,119 kg), and inability to fish in areas of high seal risk (910 kg). Total estimated catch losses were 267,177 kg, 6.6 times larger than reported landings in the fishery (Table 6). Estimated cost of gear repairs (including time) totaled $71,632, which is 15% larger than the landed value of the fishery. Total cost of seal-gear interactions was estimated as $482,902 or 775.8% of landed value.

The smelt trap-net season runs from 16 October to the end of February, although the majority of fishing occurs through the ice in January and February. The fishery is effort limited through restrictions on season and gear. Gear is set in estuaries and bays.

Most (93.5%) trap-net smelt fishers reported seal interactions (Table 4). Loss per respondent was

estimated as 8,581 kg, due primarily to inability to fish in high seal-risk areas (3,284 kg) and to seals scaring fish away from gear (3,170 kg) (Table 5). Total estimated catch losses were 481,273 kg, 4.0 times larger than reported landings (Table 6). Estimated cost of gear repairs (including time) totaled $52,942, or 27% of the fishery's landed value. Total cost of seal-gear interactions was estimated as $840,332, 424.7% of landed value.

Fishers reported that seals commonly patrol trap-net leaders, with the consequence that few or no fish are caught. Seals also follow smelts into the trap. According to fishers, harbour seals entrapped in a smelt net typically drown, whereas the larger grey seals are able to break through the netting, damaging or destroying the net in the process. One fisher reported seeing grey seals outside a trap-net chasing smelts from one side of the trap-net to the other, causing the smelt to mesh. The seals then tore the heads from the smelts from the outside of the webbing.

Seven smelt fishers were contacted for follow-up interviews. All reported that catches of smelts drop drastically when seals move into an area. They felt that fishing was generally not feasible in the presence of seals because the diminished catches are not worth the time and cost of removing fish heads and dead seals, and repairing and replacing damaged gear.

Eels (*Anguilla rostrata)* are trapped in fyke (funnel) nets from 16 August to 31 October. The fishery is effort limited through restrictions on season and gear. Ten of 29 (34.5%) eel trap-net fishers reported seal interactions with their gear (Table 4). Mean reported loss was 354 kg, due primarily to inability to fish in areas of high seal risk (113 kg) and to fish escaping through holes made by seals (90.7 kg) (Table 5). Total estimated cost of interactions was $49,877, 30.0% of landed value.

Silversides are fished with trap-nets in bays, estuaries, harbours, and coastal lagoons beginning 1 October. The season closes on 31 December but gear is removed before ice formation. The fishery is effort limited through restrictions on season and gear. All but one (15 of 16, 93.8%) respondent who fished silversides reported seal interactions (Table 4). Mean reported catch loss due to seals was 56,385 kg, the highest for any fishery. Losses were attributed primarily to inability to fish in areas of high seal risk (20,233 kg) and to seals scaring fish away from gear (18,496 kg) (Table 5). Total catch loss was estimated as 1,057,220 kg, which is 4.4 times greater than reported commercial landings (Table 6). Total cost of seal interactions with silverside gear was estimated as $479,132, which is 465.9% of landed value.

One interviewed fisher reported seeing seven seals every night moving along the leader of a silverside trap, scaring fish away from the trap entrance. As with the smelt fishery, silverside fishers often stop fishing once seals move into the area where the traps are located.

The gaspereau (*Alosa pseudoharengus* and *A. aestivalis*) gillnet fishery occurs in inshore waters in May and June. The fishery is effort limited through restrictions on season and gear. Nine of 28 (32.1%) respondents who gillnetted gaspereau reported seal interactions (Table 4). Mean loss per respondent (90.7 kg) was evenly divided among holes made by seals, seals eating fish in nets, and seals scaring fish away from nets (Table 4). Total economic loss was estimated as $21,170, which was largely due to the time and cost of repairing gear. Total cost was 171.1% of reported commercial landed value.

The gaspereau trap-net fishery occurs in May and June (with week-end closures) in estuaries. The fishery is effort limited through restrictions on season and gear. Two of four gaspereau trap-netters reported seal interactions (Table 4). Estimated loss was 454 kg per respondent, due entirely to seals scaring fish away from gear (Table 5). Total cost was estimated as $910, 5.9% of the value of reported commercial landings.

Prince Edward Island fishers fish bluefin tuna (*Thunnus thynnus*) in local waters, and also in Chedabucto Bay, between Nova Scotia's Eastern Shore and Cape Breton Island, and off southwestern Nova Scotia. The fishery is subject to a fleet quota. In most years the quota is not attained, but the difference between landings and quota is usually small. The season starts in mid-July to mid August, depending on location, and concludes by mid-fall. One half (12 of 24) of respondents who fished tuna reported seal interactions (Table 4). Interviewed fishers indicated that seals often interfere with the fishery by stealing bait and damaging gear. Three respondents reported that seals ate chum spread on water to attract tuna, and one noted that seal interactions with herring nets interfered with his bait supply. Interference was reported to be most common in the Chedabucto Bay area. One interviewee stated that he hooked at least one grey seal per hour while fishing in that area. Interviewed fishers said that although seal interference was frequent, catch losses could not be estimated because catching a tuna is a rare and unpredictable event. No respondents gave quantitative estimates of catch loss (Table 5). Economic cost of gear interference due to time and money spent repairing gear was $21,583, 5.6% of landed value (Table 6).

Based on respondent reports, losses due to seal interactions in all fishery sectors totaled $6. million in 1997, which was 6.1% of the total landed value of the PEI fishery (exclusive of aquaculture production) (Table

6) Estimated losses in the estuarine sector (smelts, eels, silversides, gaspereau) totaled $1.9 million, or 30% of the total loss for all fisheries. Estimated estuarine loss was 3.4 times greater than the landed value reported for estuarine finfish ($544,302).

In 2000, the waters adjacent to Governors Island (Fig. 1) were closed to direct harvest of bivalve shellfish because coliform counts in the area exceeded legal thresholds during tests conducted in 1999 (measurements had not been taken in previous years). There is a small oyster fishery on Governors Island. The closure ended harvest of oysters for direct sale. However, fishers were permitted to remove oysters from the closure zone and re-lay them in clean water for subsequent harvest, which is a common practice in the PEI bivalve shellfish fishery (Jenkins et al. 1997).

Governors Island is an area of concentration for harbour and grey seals (Fig. 2). The island also has a colony of double-crested cormorants (*Phalacrocorax auritus*) with 1,371 nests, and a colony of great blue herons (*Ardea herodias*) with 71 nests (2000 census data, R. Dibblee, PEI Fish and Wildlife Division, pers. comm.). Charlottetown harbour is a shellfish contaminated zone due to incompletely treated sewage, but Governors Island is 8 km away from the Charlottetown closure zone. This leaves the seals, the colonial nesting birds, or both, as the most likely cause of the coliform contamination at Governors Island.

Seal mortalities

Mean number of seal deaths per respondent as calculated from raw data was similar to mean deaths per respondent calculated from a data set in which values greater than the mean + 2SD were excluded (Table 7). Total numbers of seals dying due to gear interactions were estimated as the product of the mean number of deaths per respondent calculated from raw data, the proportion of respondents reporting seal-gear interactions, and the number of active fishers.

Seal mortalities were reported in all fisheries covered in the questionnaire except the rock crab fishery (Table 7). The largest estimated mortalities occurred in the smelt trap-net fishery (208.7) and the tuna fishery (180.8). More than 50 seals were estimated to have died following interactions in each of the mackerel, herring, and flatfish gillnet fisheries, and the lobster fishery. Total mortality estimated for 1997 was 790 seals. Based on comments made by fishers and personal observations, the majority of seals killed in the smelt trap-net fishery are probably harbour seals. Comments in the questionnaires suggest that most seals killed in the tuna fishery are greys, and much, perhaps most, of this mortality occurs on the Atlantic coast of Nova Scotia rather than in PEI waters.

Mitigative measures

Only small numbers of respondents indicated measures to avoid or reduce seal-gear interactions (Table 8). In the lobster fishery, 11 respondents (6.3%) reported using a bait bag to reduce risk of seals stealing bait. Ten (5.7%) used smaller entrance rings for the same purpose. Two respondents adjusted the bait string or toggles, one used steel bait boxes, one nailed lathes across entrance rings, and one slanted the trap rings to make it more difficult for seals to reach the bait.

Some respondents who used bait bags expressed concern that traps fitted with bags may not fish as well as traps that are baited conventionally. One respondent estimated the cost of bags as $400-$600 for a fleet of traps. Extra baiting time was estimated by two respondents. One said filling bait bags took three extra hours per day, which amounts to 154 hours in a 60 day fishing season, assuming that traps are re-baited six days per week. The other respondent said the task required 40-50 hours per season. The mean of these estimates is 100 hours per season.

Cost of using bait bags can be estimated as follows:

A - Minimum proportion of fishers using bags: 11/175 = 0.063 (Tables 4 and 8)
B - Number of active lobster fishers on PEI: 1307 (Table 6)
C - Mean of estimates of bag costs per fleet of traps: $500
Mean cost of bags = ABC = 0.074*1307*500 = $41,077.

D - Mean hours per year in extra baiting time: 100
E - Hourly wage: $10
Labour cost of bag use = ABDE = 0.074*1307*100*15 =$96,718

Total = $41,077 + $96,718 = $137,795.

This assumes that bait bags will last one season, and will need replacement annually. The calculation also assumes that all respondents who fished lobster and used bait bags indicated that they did so in the question on mitigative measures (Question 9, Appendix 1). If some respondents who fished lobster and used bait bags left this question unanswered, then the estimated cost of bait bags would be downwardly biased.

The respondent who used steel bait boxes indicated that they were effective in deterring bait stealing, but noted their expense ($3.50 per box). The respondent who nailed lathes across the entrance felt that this helped reduce risk of bait stealing, but that it also interfered with entry of lobsters, especially large ones, into the trap. The respondent who fitted his trap rings in a slanted position reported that this reduced bait

stealing, and did not mention any change in trap efficiency.

Respondents who decreased the size of trap rings reported that the smaller rings deterred bait stealing to some extent, but that losses continued due to seals breaking the rings to reach the bait. Respondents who used smaller rings also felt that the smaller entrances reduced their catches of large lobster.

The possibility of using salted bait to reduce seal interactions (Mansfield and Beck 1977) was raised during interviews with lobster fishers. However fishers felt that such bait would be less attractive to lobster than conventional bait, and would therefore reduce catches.

In finfish fisheries, most responses (41 of 47) involved avoidance of seals in time or place, either by moving gear away from seal concentrations, by fishing at different times, or by stopping fishing altogether (Table 8). Moving gear out of areas of seal concentrations was reported to reduce gear conflicts to some degree, but respondents felt that such relocations reduced their fishing income because the new locations had poorer fishing success. One smelt fisher, who fished in the mid-estuary of a river, noted increased competition from other fishers who had moved from the lower estuary/bay to avoid seal-induced damage there.

Smelt fishers commonly noted that certain areas could not be fished profitably because of high seal risk. Four smelt trap-fishers reported ending fishing early due to excessive gear interactions (Table 8). Smelt fishing was viewed as more vulnerable to seal interference during open water than in the ice-covered season. However, one respondent who fished in winter stated that trap-nets must be 7 km or more from open water to be safe from seals.

Two smelt trap-netters reported putting coarse-mesh netting across the trap mouth to bar seal entry. This was effective in keeping seals out of the trap, but the seals nevertheless damaged fish in the trap by pressing against one side and biting the fish through the trap wall.

One smelt trap-netter dipped his gear in tar, which he reported to be an effective means of preventing fish from meshing in the trap walls in the presence of seals.

One silverside fisher reported tying corners of the trap so that it would hold its shape better when pressed by seals. Two other respondents attached covers to their traps to prevent seal entry. These practices achieved their immediate goals, but catches were still reduced because seals patrolled the leaders, catching fish before they could enter the trap.

J. Lien (Memorial University of Newfoundland, pers. comm.) has suggested that escape vents placed on the covers of smelt, silverside, and gaspereau trap-nets might reduce damage to these gears by allowing trapped seals to exit. Seals in PEI waters are experienced in finding holes in ice, so they ought to be able to locate and use a roof vent. If nets are set in such a way that the cover is underwater at high tide, a simple hole in the roof would allow fish to escape from the trap. This problem could be solved by attaching a "chimney," consisting of netting held up by surface floats, to the roof hole.

If escape vents work as intended, gear damage to trap-nets would be reduced. However, fishers felt that catch losses would not be reduced because seals would presumably eat all the fish in the trap before leaving, and would still fish the leader. A roof vent might also provide an easier way for seals to enter the trap.

Acoustic deterrent devices (ADDs) make underwater sounds that are intended to frighten predators. Underwater firecrackers, arc-discharge transducers, electronic noise-makes, rifle shots, and killer whale (*Orcinus orca*) vocalizations have been used to repel seals from nets, but the deterrent effect of these devices was generally short-lived because seals habituated to the sounds (Shaughnessy et al. 1981, Pemberton and Shaughnessy 1993). Electronic ADDs have been used in the salmon aquaculture industry of southwest New Brunswick (E. Trippel, Department of Fisheries and Oceans, pers. comm.). These devices produce very loud sounds, but their effectiveness is also limited, possibly because the extreme noise levels they produce damage the hearing of seals so the sound may lose its deterrent effect (J. Lien, pers. comm.).

The possibility of using ADDs in PEI was discussed with fishers. It was universally felt that ADDs would not contribute to a reduction in the cost of seal-gear conflicts on PEI, given their high purchase price and their poor record of protecting gear elsewhere.

Six respondents reported they had abandoned fishing the species/gear due to seal interactions (one herring gillnet, two smelt gillnet, two smelt trap-net, one eel trap-net).

Many respondents suggested, often forcefully, that the only solution to seal-gear conflicts is a large-scale cull.

Seal diet

All 11 harbour seals stomachs obtained from the winter smelt fishery contained prey (Table 9). All stomachs contained smelts, and eight contained "many" smelts. Tomcod (*Microgadus tomcod*) were present in all stomachs, and winter flounder were present in all but one stomach.

Eight respondents to the written questionnaire reported having witnessed seals eating lobsters. One of these respondents was from the Alberton area of Prince North, the others were from Kings County. Two respondents reported seeing harp seals eating lobsters and one reported seeing grey seals eating lobsters. The others did not indicate the seal species. One respondent reported seeing seals eating egg-bearing lobsters that had been released from a boat, and another reported having seen seals with market-sized lobsters in their mouths.

One respondent reported seeing seals shake lobsters until the claws fell off, and then eating the lobster body. Two respondents reported having seen lobster claws on beaches in the St. Peters area, which they attributed to the above-noted method of feeding. One of these reported that the claws he had seen were meat-filled, which was taken to indicate that the claws were not from lobsters that had been fished commercially and eaten.

Two respondents suggested that the large herd of harp seals that visited the area between North Cape and Tignish in spring 1996 may have preyed heavily on lobster, causing a decline in local lobster landings in that year. Harp seals were also sighted along the shoreline as far east as Rustico in spring 1996. To examine the possible relation between harp seal visitation and lobster landings, we compared landings from the ports close to the main herd (Seacow Pond and Tignish), from ports in the area where harp seals were sighted in lesser numbers (Alberton to Rustico), and from ports east of the area of harp seal visitation (Covehead to North Lake). Lobster landings in 1996 were significantly lower than those of 1994-1995-1997-1998 at Seacow Pond and Tignish ($P=0.045$, Anova). Landings in 1996 did not differ significantly from those of other years in the Alberton-Rustico and Covehead-North Lake areas ($P>.05$). In all three areas, landings declined between 1995 and 1996, and the decline was steepest in the Alberton-Rustico area (Fig. 9). Given that lobster landings declined in an area not visited by harp seals, and that the steepest decline occurred in an area only lightly visited by seals, the hypothesis that harp seals caused the reduction in lobster landings in Seacow Pond/Tignish in 1996 is not supported.

DISCUSSION

Response rate and response bias

The initial questionnaire mail-out had been planned for November, but was delayed until 9 December by a postal strike. The arrival of questionnaires in the pre-Christmas period may have been responsible for the low response rate (9%) to this mail-out. The return rate from the second mailing in early January (19.1%) was more than twice as high.

Conversations with fishers indicated that some did not respond because of antipathy to the PEI Fishermen's Association, which was listed as the questionnaire sponsor. Others may have declined to respond due to sentiments expressed by one fisher who wrote "This study is a waste of time and money. We all know what should be done with seals!"

We conducted telephone interviews with randomly selected fishers who had not returned their questionnaires because we anticipated that fishers with a high level of seal-gear interaction would be more likely to answer questionnaires than those with a low level of seal interactions. However, no evidence was found for such a bias because seal interaction frequencies reported by the two groups did not differ significantly (mail-out, 58.9%; phone, 53.4%; $P>0.29$).

Lien et al. (1994) proposed that fishers tend to report numbers on a non-linear scale of "1 - 2 - 3 - 4 - 5 - dozens - hundreds - thousands," and cautioned that means may be unduly influenced by a small number of very high values which are reported with a low level of reliability. To test for this effect, we compared means calculated from raw data sets and from truncated data sets in which extreme values were discarded, for fishers' reports of peak seal numbers, seal-induced catch loss per fisher, and number of seals killed by gear interactions. Means calculated in the two ways differed greatly for peak seal numbers, suggesting that the effect suggested by Lien et al. (1994) was present. However, truncation of the data set produced only small differences in means for catch losses and seal deaths, suggesting that means were not strongly influenced by extreme values.

Distribution, numbers, and seasonal trends

Data reported in this study cannot be used to estimate populations of seals frequenting Prince Edward Island waters. We did not request species to be specified in questions on peak seal numbers, population trends, and timing of seal presence because we were uncertain as to the reliability of species identification by fishers. We also felt that asking for species identification throughout the questionnaire would increase its length and lead to a lower response rate.

A small number of respondents reported very high peak numbers of seals in their areas ($\geq$10,000). These reports presumably refer to large herds of harp seals. Comparison of median peak numbers from a data set which discarded extreme values suggests that highest local populations of seals exist in Prince North and Kings South (Table 1). Lowest reported populations were in Queens North.

Harbour seals pup in late spring on beaches, and the newborn animals often enter the water shortly after birth

(Boulva and McLaren 1979). Young pups may at times move to beaches other than their natal site; hence sightings of pups on beaches do not necessarily reflect the exact location where whelping occurred. It is also possible that haul-out sites that include sub-adult animals may have been reported as pupping sites.

Reports from respondents suggest that Kings South, particularly the Murray Harbour area, is the major breeding ground for harbour seals in the province (Fig. 4). Pupping also occurs in Hillsborough Bay, in Queens South. The three commercial seal tour operations on PEI (to Governors Island in Hillsborough Bay, to the Murray Islands, and in Cardigan Bay) are all located in areas where harbour seals are reported to pup. Of the 37 reports of pupping sites, all but 5 were from Queens South and Kings South (Fig. 4).

Necropsy records from the Atlantic Veterinary College are not unbiased indicators of seal distribution, because only seals that are dead or that have been in distress are likely to be necropsied, and because specimens are not obtained through any kind of organized or systematic survey. Nevertheless these records may give a rough indication of species distribution. Necropsied harbour seals came exclusively from Kings South and Queens South, although other species were abundant in samples from the north shore and from Prince South (Table 3, Fig. 8). This reinforces the suggestion from the pupping site reports that harbour seals are concentrated chiefly in southeastern PEI. In the absence of confirmed identifications, we cannot say if, and to what extent, harbour seals also occupy PEI's north shore and Prince South.

Harbour seal populations in Atlantic Canada have never been reliably censused. Boulva and McLaren (1979) estimated an eastern Canadian population of 12,700 in 1973 on the basis of questionnaires, reports of bounty kills, and interviews. Harbour seal numbers appear to be increasing in the Bay of Fundy, on the Nova Scotia coast, and in the St. Lawrence estuary (Hammill and Stenson 1997). The eastern Canadian population was estimated as 31,900 animals in 1996 (Hammill and Stenson 2000).

Boulva and McLaren (1979) estimated that Prince Edward Island harbour seals numbered 470 in 1973. Harbour seals were distributed in southeastern Kings County from Cape Bear to Spry Point (250), Hillsborough Bay (188), Bedeque Bay (10), Cascumpeque Bay (10), and the North Rustico area (20). On the basis of regional breakdowns reported by Boulva and McLaren (1979), Hammill and Stenson (1997) estimated a southern Gulf harbour seal population of 2,157 in 1996.

Most grey seals in eastern Canada pup on Sable Island, or on the pack ice of the central and eastern Northumberland Strait between Prince Edward Island and Nova Scotia. The Gulf grey seal population was estimated to number 59,712 in 1996, with an annual population increase of 6.8% (Hammill and Stenson 1997).

After the January-February pupping season, Gulf grey seals disperse broadly throughout the Gulf of St. Lawrence, until their return to the Northumberland Strait pupping area in late fall (Clay and Nielson 1985, Lavigueur and Hammill 1993). The grey seals reported by respondents to this survey are among those that remain in the southern Gulf. Necropsy reports (Table 3) confirm that grey seals are widely distributed around Prince Edward Island.

Harp seals in the northwest Atlantic pup in spring on the ice off northeastern Newfoundland and in the Gulf of St. Lawrence. The Gulf component of the population included about 400,000 adult seals in 1996 (Hammill and Stenson 1997). In most years, pupping occurs in the general area of the Magdalen Islands and harp seals do not approach PEI in appreciable numbers. However, in some years poor ice forces the harp seal herd south toward Prince Edward Island, and large numbers of animals may be found in inshore waters or even on beaches. Such events occurred in 1969, 1981, 1996, and 1998, and may increase in frequency if mild winters and poor ice conditions become more common.

Although the main visitation of harp seals to the southern Gulf of St. Lawrence occurs in late winter and early spring, necropsy records indicate that some harps are present in PEI waters year-round (although this does not necessarily mean that individual harp seals stay in PEI waters year-round). In fact more harp seals were necropsied from winter (17, December-February) than spring (14, March-May), and the species was also present in necropsy samples in summer and fall (Table 3).

The general increase in the harp seal population has been accompanied by an increase in extra-limital occurrences. Sightings of harp seals increased greatly in the Bay of Fundy and Gulf of Maine in the 1990s (McAlpine et al. 1999, McAlpine and Walker 1999). Due to the paucity of data in early years, it is not known whether visitation of harp seals to PEI at unexpected times of the year has been increasing.

Like harp seals, hooded seals pup on the ice in spring, and a portion of the northwest Atlantic stock uses the Gulf of St. Lawrence for pupping. The Gulf component of the population was estimated as 13,471 in 1996 (Hammill and Stenson 1997).

Most hooded seal pupping takes place in the southeastern Gulf in the triangle between the Magdalen Islands, Cape Breton Island, and PEI (Hammill 1993). In some years ice conditions may bring hooded seals close to PEI shores, but necropsy records indicate that some animals also visit the area in summer and fall (Table 3). Like harp seals, hooded seals appear to be undergoing a range expansion, with increasing numbers being reported from the Gulf of Maine area (McAlpine et al. 1999).

According to respondents' reports, seals were present most often from April to November. However, the preponderance of reports in the open-water season may reflect the fact that most fishing, and therefore most opportunities to see seals, occurs in these months.

Reliability of estimates of gear interaction costs

The data sources used in this study are subject to error and biases which reduce the reliability of loss estimates. Most ($5.6 million of $6.2 million, 90%) economic losses estimated from respondent reports are due to catch losses (Table 6). Such estimates are highly subjective, because (with the exception of gilled fish that are partly eaten by seals) fishers are estimating quantities of fish that they have not seen or caught. Catch losses due to inability to fish in areas of high seal risk were $1.2 million, 20% of total estimated losses (Table 6). Losses due to this source would be particularly subjective because the fisher is not fishing in the areas for which lost catches are estimated.

The estimated cost of repairing or replacing gear damaged by seals was $607,387, or 10% of total estimated loss. This estimate is based on fishers' personal experience of time spent and expenditures made. However there is also a subjective element in these estimates because they are based on memory rather than on written records.

It is well known that many fishers do not like seals. This may lead to overstatements of losses. To evaluate the likelihood of loss exaggeration, we compared loss estimates with landed values in estuarine finfish fisheries. For the smelt and gaspereau gillnet fisheries, the estimated time and dollar cost of repairing and replacing gear exceeded the reported landed value of the fisheries by 15% and 56%, respectively (Table 6). In the smelt gillnet and trap-net fisheries and the silverside trap-net fishery estimated seal-induced losses were 7.8, 4.2 and 4.7 times, respectively, greater than reported landed values (Table 6).

If repair costs exceed landed value, then a fishery is operating at a loss. It is also implausible that losses due to seals would be several times the value of the fishery. Landed values for estuarine species on PEI are of doubtful reliability (Cairns 1997). If landed values are underreported, then ratios of seal-induced losses to landed values would be inflated. If labour used to repair fishing gear is supplied at a discounted rate (much less than the $100/day used in the estimates), then net losses due to seal damage in the smelt and gaspereau gillnet fisheries might be reduced or eliminated.

Although the above-noted factors may have some influence on loss estimates, it seems unlikely that they fully account for the high multiple of estimated loss compared to landed value in the smelt and silverside fisheries. We conclude that many respondents who prosecuted estuarine fisheries overstated their catch losses and their reports of the time and dollar cost of gear repair and replacement, thereby inflating total loss estimates above their true value.

Estuarine fisheries are more strongly affected by seal-gear interactions than are other sectors of PEI's fishery. In most non-estuarine fisheries, estimated cost of seal-gear interactions were a low fraction of total landed value (Table 6). We have no independent means to determine whether respondents overstated losses in these fisheries. However, given the evidence from the estuarine sector, and the general sentiment of fishers toward seals, we consider it very likely that losses are overstated by many respondents, with a resulting upward bias in estimates of total losses.

This survey does not address all losses arising from seal interactions with fishing gear. The questionnaire asked respondents to estimate losses in fisheries in which they were actively engaged. It did not register losses due to fishers having given up fishing a certain species because of seal interactions. Fishers who have smelt licences on Prince Edward Island commonly hold mollusc licences as well. Our survey did not account for possible negative effects of increased competition in the mollusc (clam; oyster, *Crassostrea virginica*) fisheries due to smelt fishers having given up smelt fishing because of seal-induced losses.

The cost of mitigative measures is also not included in our totals. Based on information supplied by respondents, we estimate that use of bait bags cost the lobster industry $137,795 in 1997. This must be considered a very rough estimate given the many uncertainties that went into the calculations. The addition of covers to silverside traps and barrier nets at the entrance to smelt traps are mitigative techniques which cost money, but we have no estimates of their costs.

The survey did not register catch loss in the tuna fishery because respondents felt they could not estimate it. However, seal-gear interactions in that fishery are frequent, and may have some effect on catches.

If seals cause gear damage in a quota-limited fishery in which the quota is fully caught, then seal damage will not diminish total landings, although it may increase the cost of catching the fish and therefore decrease fishers' net income. Among the fisheries considered in this survey, the snow and rock crab trap fisheries, the flatfish, herring, and mackerel gillnet fisheries, and the tuna baited hook fisheries are subject in whole or in part to boat or fleet quotas. Of these, only the snow crab, rock crab, and flatfish fisheries land their full quotas in most years. Part of the herring gillnet fishery reaches its quota, but the largest fishery (at the eastern end of PEI) does not. Total cost of seal-gear interactions in the snow crab, rock crab, flatfish, and herring fisheries, based on respondent reports, was $292,384. This is 4.2% of the total estimated cost of seal-gear interactions in all fisheries. Hence the fact that landings in some fisheries are limited by quotas is not a major source of bias in the estimate of the total cost of seal-gear interactions.

To sum up, our estimates of the cost of seal-gear interactions are upwardly biased due to the tendency of fishers to overstate losses, and downwardly biased because our survey did not address certain types of losses. Overall, we consider that upward biases are likely to be much greater than downward biases. This means that the true cost of seal-gear interactions is likely much lower than the $6.2 million calculated from respondent reports. Nevertheless, it is clear that seal-gear interactions are widespread, and that losses are substantial for some fishers, particularly those in the estuarine sector.

Three other questionnaire surveys of seal-gear interactions have been completed in the Maritime Provinces. Mansfield and Beck (1977) estimated that seals caused $450,000 of damage annually to gillnets on the Atlantic shore of Nova Scotia from Ship Harbour, Halifax County, to Scatari, Cape Breton. Using a revised methodology and a different survey sample, Zwanenburg and Beck (1981) estimated seal damage to stationary gear in the same area to be worth $157,000. Farmer and Billard (1984) surveyed fishers on the Fundy and Atlantic coasts of Nova Scotia, and estimated that seals caused damage worth $1,076,430 to inshore gear. It can be concluded from these reports that seal damage to fishing gear in Nova Scotia in the late 1970s and early 1980s was probably substantial. However, due to varying survey methodology which in some cases was incompletely described, it would be difficult to compare losses estimated in the present study with those reported in the Nova Scotia investigations.

Patterns of gear interactions

In general, seal-gear interactions occur most frequently in fixed gear (Northridge 1986), although some mobile gears are also affected (e.g. South African purse seines, Wickens 1994; Newfoundland groundfish trawlers, Pemberton et al. 1994).

The majority of Prince Edward Island's fisheries are prosecuted with fixed gear. The only mobile sector covered by this survey was the tuna fishery, in which seals, mostly greys, become caught on baited hooks. Prince Edward Island tuna fishers have access to Nova Scotia waters, and respondent reports suggested that seal interactions were more frequent there than in home waters. Seals also interfere with hook-on-line fisheries in California (salmon trolling, DeMaster et al. 1985) and in South Africa (longlining, Wickens et al. 1992).

The PEI fishery suffering the greatest seal-induced cost is the lobster industry, whose estimated total losses ($3.2 million) account for about one half the total of estimated losses (Table 6). Landed values of the lobster industry amount to about 75% of total value of all PEI fish landings. Hence the estimated impact of seal-gear conflicts on the lobster industry is a small percentage (4.4%) of landed value. Seal interference with lobster traps has previously been reported by Mansfield and Beck (1977) and Farmer and Billard (1984). Robinson and Dennis (1988) noted that seals commonly raid rock lobster traps in Australia. In South Africa, rock lobster traps are not subject to seal interference, but seals may take undersized rock lobsters as they are returned to the water (Wickens et al. 1992).

The Prince Edward Island snow and rock crab fisheries are also prosecuted with rigid-frame traps, but seal interference with these gears resulted in little damage.

Questionnaire results indicated substantial seal interactions with gillnets, including stealing fish from nets, damaging nets, and scaring fish away from nets. Conflicts occurred in open water (flatfish, herring, mackerel, gaspereau), estuaries and bays (smelts), in surface sets (mackerel, gaspereau, smelt), and in bottom sets (flatfish). Herring are gillnetted in Prince Edward Island waters using surface sets in spring and bottom sets in fall. Respondents reported seal interactions in the spring herring fishery, but our data do not indicate whether interactions also occurred with bottom-set gillnets in the fall. Seal interactions with gillnets are commonly reported in many fisheries, including groundfish gillnets in Newfoundland (Northridge 1986), Nova Scotia (Mansfield and Beck 1977, Zwanenburg and Beck 1981, Farmer and Billard 1984) and the Gulf of Maine (Waring 1994), tangle nets in Ireland (Collins et al. 1993), and salmon nets in Ireland (McCarthy 1985) and the eastern Pacific (Fiscus 1980).

Estimated losses due to seal interactions with flatfish, herring, and mackerel gillnets in non-estuarine waters ranged from 6.1 to 33.1% of reported landed values (Table 6). Seal losses were estimated to total 776% of landed values in the smelt gillnet fishery and 171% of landed values in the gaspereau gillnet fishery. These values are not credible, but they do suggest that seal interactions are widespread and costly to the smelt and gaspereau gillnet fisheries.

The questionnaire covered trap-net fisheries for smelts, eels, silversides, and gaspereau. Smelts, silversides, and gaspereau trap-nets are large enclosures with long leaders. It is not surprising that such traps attract seals, given the large volume of fish that they hold. The presence of leaders, which divert fish from their normal movements and concentrate them along a barrier, also provides fishing opportunities for seals. Seal predation along leaders removes fish which would otherwise enter traps, and, according to respondents, reduces catches by scaring fish from the general area.

Questionnaire results indicate a high incidence of seal interference with smelt and silverside trap-nets (425 and 466%, respectively, of landed values). These values are implausibly high, but they nevertheless indicate severe gear conflicts in these sectors.

Respondents reported a low level of interaction with gaspereau trap-nets (5.9% of landed values). The relative lack of gear conflict in this fishery may be due to the location of these nets. Many gaspereau trap-nets are set in the upper portion of estuaries where seals are less common.

Trap-nets used for eels on Prince Edward Island consist of a leader and a series of funnels, and have a much smaller volume and lower catch rate (kg/day) than smelt, silverside, and gaspereau trap-nets. Relative losses due to seal interactions with this gear (30% of landed value) were smaller than those of trap-net fisheries for smelt and silversides, but greater than those of the gaspereau trap-net fishery.

Seal interference has been reported in trap-net fisheries for salmon, mackerel, and herring (Mansfield and Beck 1977, Bonner 1982).

Although reports of seal interference with fishing gear were widespread in questionnaire results, it must be emphasized that not all fishing activity results in seal-gear conflicts. Of the 676 fisheries reported by respondents, 42% had no reported seal interactions (Table 4). The majority of lobster, snow crab, and rock crab fishers reported no seal-gear interactions in these fisheries. Our questionnaire did not specifically address fisheries for molluscs, marine plants, and trawl and seine fisheries for finfish. Although many respondents commented at length about many aspects of seal-fisheries relations, no report was received about any interaction between seals and gear used in mollusc, marine plant, seine, and trawl fisheries. On this basis we conclude that seals do not interfere in any significant way with gear used in these fisheries on PEI. Landed value of these fisheries was $14.5 million in 1997, or 14% of total landed value.

Seals may have affected the bivalve shellfish industry by contributing to the coliform levels that triggered the closure of waters around Governors Island to direct harvest. However, the relative contributions of seals and colonial nesting birds to coliform densities at Governors Island are unknown. Harbour seals in Washington State have been reported to cause shellfish closures by raising coliform levels (Nash et al. 2000).

Seal mortality

This survey indicates that seal deaths due to interactions with fishing gear on PEI are numerous, and widely distributed among gear sectors. Together, smelt trap-nets and tuna hooks accounted for about one half of all estimated mortalities, and the remainder were distributed among trap, gillnet, and trap-net fisheries (Table 7). The total number of deaths (790) is an overestimate for PEI, because some, perhaps most, of the estimated 180.8 seal deaths due to tuna gear interactions occurred in Nova Scotia waters.

Based on fishers' reports, mortalities in trap-net fisheries (estimated total 278) appear to primarily affect harbour seals. This is supported by the species composition of seals sampled from winter smelt trap-nets for diet analysis (all 11 were harbour seals). Tuna fishers indicated that most seals which died following conflict with tuna gear were grey seals. Mortalities in the trap and gillnet fisheries are probably a mix of seal species, possibly with a preponderance of harbour seals which, due to their small size, are less able to break free of enmeshing or entrapping gear. The extent to which harp and hooded seals suffer gear mortality in PEI waters is unclear. In their normal migratory cycle these species should be absent from the PEI area during the open water season when most fisheries occur. However necropsy reports (Table 3) suggest some year-round presence in PEI waters.

Seal mortality in fishing gear is commonly reported in many fisheries worldwide, including those prosecuted by gillnets, trap-nets, hooks, purse seines, and trawls (Bonner 1982, DeMaster et al. 1985, McCarthy 1985, Pemberton et al. 1994).

Mitigative measures

Mitigative measures adopted by respondents to this survey can be classified as modifications to gear and

fishing methods, or as avoidance of fishing at times or in places where seal risk is high.

Most gear modifications reported by respondents were in the lobster fishery (Table 8). Respondents enclosed bait in bags or reduced the size of trap entrance rings to lower the risk of seals stealing the bait. In general respondents felt that these measures achieved their intended effects. However, bait bags cost money and extra labour to fill them, and there is a widespread concern that bait containment systems and reduction of entrance ring size may reduce lobster catch rates.

Gear modifications to trap-nets included covering the tops of silverside traps and placing barriers in front of smelt nets. Respondents felt that these measures helped keep seals out of the traps, but gear damage and catch losses continued because seals reacted by fishing from the outside of the net and along the leader.

Other potential methods of reducing seal-gear damage include ADDs and escape vents in trap-nets. ADDs have little chance of success because of their high cost and low effectiveness. Escape vents might reduce gear damage, but fishers are unlikely to adopt them because they feel they will not reduce catch losses.

Most respondents who reported changing the place or time of fishing to avoid seal conflicts fished for estuarine species, particularly smelt and silversides. Shifting location of gear was felt to reduce seal risk, at least until seals began visiting the new location. However, there is usually an economic cost to such shifts because an original location, chosen because it produces the best economic yield, must be abandoned for another location selected on the basis of lower seal visitation. In general, alteration of time of fishing means reduction of time of fishing, because any periods when fishing is profitable are probably already utilized. Hence fishers who encounter severe seal problems in an area, and for whom alternate fishing sites with low risk are not available, often feel that their only choice is to remove their gear and stop fishing.

Many respondents to this survey proposed that Prince Edward Island seal populations be reduced through a cull. To be effective in reducing seal-gear interactions, such a cull would have to affect both harbour and grey seals. Harbour seal populations are low and unreliably known in eastern Canada. Grey seals that visit PEI are part of a large Gulf population; this entire population would presumably have to be reduced to effect a decrease in grey seal numbers on PEI. Arguments for and against culling are complex, and include political as well as biological considerations (Harwood and Greenwood 1985, Gulland 1987a and b, Butterworth 1992, DeMaster and Sisson 1992, Smith 1995).

Diet

Harbour, grey, harp, and hooded seals in the Atlantic region take a wide variety of benthic, pelagic, and estuarial finfish, and invertebrates (Hammill and Stenson 2000).

Fisher and Mackenzie (1955) reported that harbour seal stomachs taken from June to October in Pownal Bay, PEI, eastern Nova Scotia and southern New Brunswick contained mostly herring, winter flounder and other flatfish, gadids, and gaspereau. However, these authors did not specify which samples came from PEI. Boulva and McLaren (1979) reported contents of 279 harbour seal stomachs from eastern Canada, but did not indicate locations of origin. Major prey species were herring, gaspereau, hake, smelt, mackerel. In the lower Bay of Fundy and the northeastern coast of Nova Scotia, the major prey of harbour seals is herring, cod, pollock, short-finned squid, and hake (Bowen and Harrison 1996).

For grey seals, Benoit and Bowen (1990a) compiled data from 89 food-containing stomachs from the southern Gulf of St. Lawrence, including four from eastern Northumberland Strait (season unspecified). The major prey were skates, flatfish, herring, cod, and smelt. Baker et al. (1995) examined 35 stomachs of lactating grey seals collected in January-February 1990-1991 in St. Georges Bay in eastern Northumberland Strait. Seven stomachs (20%) contained small amounts of fish remains, primarily flatfishes. The other stomachs were empty.

Harp seals in the Magdalen Islands area have been found to contain flatfish and sculpins in March (Beck et al. (1993) and herring and flatfish in April-May (Fisher and Mackenzie 1955). Stewart and Murie (1986) reported that lactating female harp seals, collected in March in various areas of the Gulf including the immediate vicinity of PEI in 1981, contained only "trivial" amounts of food, including small crustaceans and flatfish (American plaice and winter flounder).

Hooded seal diet in the Gulf of St. Lawrence has not been studied, but stomachs collected in Newfoundland contained Greenland halibut, redfish, herring, arctic cod, and squid (Hammill et al. 1997).

The winter diet of seals in the southern Gulf raises an interesting ecological question, because most common fish species are forced to leave the shallow waters of the southern Gulf to avoid lethally cold temperatures (Clay 1991). Species which largely or wholly exit the area include cod, white hake, American plaice, herring, and mackerel (Anderson and Paciorkowski 1980, Chadwick et al. 1990, Clay 1991). Winter flounder, longhorn sculpin, and some yellowtail flounder appear to remain in the area (Clay 1991). In estuarine habitats,

smelts, tomcod, and winter flounder are common winter residents. Because winter temperatures in the shallow waters of the southern Gulf, including its river estuaries, fall to well below 0°C, fish which winter there require antifreeze chemicals to prevent their body fluids from freezing (Davies et al. 1988, Chadwick et al. 1990, Ewart and Fletcher 1990).

All 11 stomachs examined during this study were from harbour seals taken during winter in smelt trap-nets. Stomachs of these animals contained smelts, winter flounder, and tomcod. This is not surprising given that the animals were taken in smelt gear, which also takes numerous winter flounder and tomcod as bycatch. However, in view of the winter out-migration of many alternate fish prey, smelt, winter flounder, and tomcod may constitute much or perhaps most of the winter diet of harbour seals in estuary and bay habitats of PEI.

Although lactating seals often fast for lengthy periods, dive profiles have suggested, and stomach samples have confirmed, that female grey seals in Northumberland Strait eat to some extent during winter (Lydersen et al. 1994, Baker et al. 1995).

Eight respondents to our survey reported witnessing seals eating lobsters. Fisher and Mackenzie (1955) and Mansfield and Beck (1977) also quote observations of harbour and grey seals eating lobsters or holding lobsters. Mansfield and Beck (1977) interpreted reports of seals with lobsters not as predation events, but rather as attempts by seals to rid themselves of lobsters which had attached themselves to the seals' noses. This explanation (the proboscis hypothesis) is inconsistent with the fishers' reports we received. If a seal is attempting to shake off a lobster that has attached itself to the seal's face, this behaviour should be conspicuous and memorable. However only one of the eight fisher's reports referred to seals shaking lobsters.

Records of lobsters in seal stomachs are rare; single records have been reported from grey seal stomachs in the Miramichi estuary (Mansfield and Beck 1977) and Anticosti Island (Benoit and Bowen 1990b). Invertebrates, including lobsters, are among the potential seal prey that remains during winter in the southern Gulf of St. Lawrence. The large influx of harp seals off northwestern PEI in spring 1996 provided an opportunity to test the notion that seals prey heavily on lobster. However, a comparison of lobster landings in areas with heavy, light, and no visitation by harp seals failed to support this hypothesis (Fig. 9).

Seals consume an estimated 763,000 tonnes of food annually in the Gulf of St. Lawrence (Hammill and Stenson 2000), an amount that is several times greater than commercial fishery harvests (approx. 200,000 tonnes, 1996 figures). However, the relations between seals and their prey are complex (Harwood 1992, Smith 1995), and an evaluation of the effects of seal predation on the Prince Edward Island fishery is beyond the scope of this paper.

CONCLUSIONS

This study has confirmed that seals have a widespread distribution in Prince Edward Island waters and that seal-gear interactions are common and are detrimental to both fishers and seals. Grey seals on Prince Edward Island are part of a larger stock whose population increase is well documented. The frequency of reports of harbour seals and the generalized increase of seal populations suggest that harbour seals may also be increasing, although specific survey data to support this are lacking. Seal-gear interactions occur in most fixed-gear fisheries and in one mobile fishery (for tuna). Seal-gear conflicts are most intense in estuarine fisheries for smelt and silversides. Seal conflicts cause widespread disruption of estuarine fisheries, and seal-induced economic losses in this sector, estimated from data supplied by fishers, exceed the landed values of targeted species. Open water fisheries for groundfish, pelagics, and crustaceans also suffer losses due to seals, but losses relative to landed values are much less than those of estuarine fisheries. Seal mortality due to interactions with smelt and tuna gear is particularly intense, but mortality also occurs in most other sectors. In the lobster fishery, modifications to trap entrances and bait containment systems reduce risk of seal-gear conflict. In other fisheries (baited hook, gillnet, trap-net), modifications that are effective in reducing seal-gear conflict have not been found. Seal-induced losses to the PEI fishery and gear-induced seal mortalities are likely to increase if seal populations continue to rise.

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Table 1
Species distribution, timing, population trends, and peak numbers of seals on Prince Edward Island, as reported by respondents to a mail-out and telephone questionnaire.

		Prince North	Queens North	Kings North	Kings South	Queens South	Prince South	Total
Questionaires returned (including phone-outs)		112	23	24	76	40	46	321
Number giving seal locations		85	14	21	68	28	30	246
Number reporting seal species		94	17	23	74	35	33	276
Number reporting:	Harbour seals	60	11	16	50	27	21	185
	Grey seals	34	9	5	31	15	15	109
	Harp seals	25	3	5	10	3	5	51
	Hooded seals	5	3	2	2	0	0	12
Percent reporting:	Harbour seals	63.8	64.7	69.6	67.6	77.1	63.6	67.0
	Grey seals	36.2	52.9	21.7	41.9	42.9	45.5	39.5
	Harp seals	26.6	17.6	21.7	13.5	8.6	15.2	18.5
	Hooded seals	5.3	17.6	8.7	2.7	0.0	0.0	4.3
Number of seals in respondent's area during peak period								
All respondents	Mean	27,919	43	883	737	144	39,981	15,512
	Median	200	23	100	200	50	100	150
	SD	164,285	62	1,567	1,632	233	195,864	121,196
	Minimum	1	2	4	30	1	3	1
	Maximum	1,000,000	200	4,000	10,000	1,000	1,000,000	1,000,000
	N	73	10	11	57	25	26	202
Respondents who did not report presence of harp and hooded seals	Mean	19,642	26	89	824	131	47,780	13,252
	Median	100	8	75	300	43	100	100
	SD	138,624	38	94	1,784	240	218,181	112,820
	Minimum	1	2	4	30	1	3	1
	Maximum	1,000,000	100	300	10,000	1,000	1,000,000	1,000,000
	N	52	6	8	47	22	21	156
Respondents who reported populations which were not greater than 5 times the median	Mean	334	25	89	310	57	119	161
	Median	200	20	75	200	36	100	100
	SD	364	30	94	283	66	141	166
	Minimum	1	2	4	30	1	3	1
	Maximum	1,000	100	300	1,000	250	500	500
	N	69	9	8	51	21	21	164
Number reporting population trends		100	21	23	72	36	35	287
Number reporting that populations are:	Decreasing	0	0	0	0	1	0	1
	Staying about the same	17	8	3	7	12	5	52
	Increasing	83	13	20	65	23	30	234
Percent reporting that populations are:	Decreasing	0.0	0.0	0.0	0.0	2.8	0.0	0.3
	Staying about the same	17.0	38.1	13.0	9.7	33.3	14.3	18.1
	Increasing	83.0	61.9	87.0	90.3	63.9	85.7	81.5
Number reporting months in which seals are present		93	20	22	71	37	37	280
Number reporting seals present in:	January	11	4	2	15	5	2	39
	February	12	1	2	14	2	2	33
	March	23	3	2	15	1	6	50
	April	43	10	10	37	8	14	122
	May	66	14	20	64	24	20	208
	June	57	11	20	63	27	23	201
	July	45	4	12	58	25	22	166
	August	46	6	14	58	25	22	171
	September	56	8	13	56	27	24	184
	October	66	8	13	49	29	24	189
	November	47	8	10	39	18	15	137
	December	24	7	4	28	11	9	83
Percent reporting seals present in:	January	11.8	20.0	9.1	21.1	13.5	5.4	13.9
	February	12.9	5.0	9.1	19.7	5.4	5.4	11.8
	March	24.7	15.0	9.1	21.1	2.7	16.2	17.9
	April	46.2	50.0	45.5	52.1	21.6	37.8	43.6
	May	71.0	70.0	90.9	90.1	64.9	54.1	74.3
	June	61.3	55.0	90.9	88.7	73.0	62.2	71.8
	July	48.4	20.0	54.5	81.7	67.6	59.5	59.3
	August	49.5	30.0	63.6	81.7	67.6	59.5	61.1
	September	60.2	40.0	59.1	78.9	73.0	64.9	65.7
	October	71.0	40.0	59.1	69.0	78.4	64.9	67.5
	November	50.5	40.0	45.5	54.9	48.6	40.5	48.9
	December	25.8	35.0	18.2	39.4	29.7	24.3	29.6

Table 2
Seals collected on Prince Edward Island and necropsied at the Atlantic Veterinary College, 1988 - spring 1999

Specimen no	Species	Age[a]	Sex	Month of death	Location	Diagnosis
1989						
15938	Grey	Adult	Male	May	West Cape	Acute trauma (skull fracture - hit by boat or shot?) (very decomposed)
1990						
13994	Harbour	Juvenile	Male	Sep	Mermaid	Emaciation
1991						
5974	Harp	Immature	Female	May	Covehead Harbour	Phocine distemper
14568	Grey	Adult	Female	Nov	?	No Dx[c] (microscopically, marked congestion of brain, lungs, liver - drowning?)
1992						
4536	Grey	?	?	Apr	St. Teresa	Emaciation (found approx. 10 km from salt water)
6062	Grey	Immature	Male	Apr	Seal River, Cardigan	Acute head trauma (shot)
9634	Grey	Immature	Female	Jun	Montague River	Severe bronchopneumonia
1993						
7527	Grey	Juvenile	Male	May	Trout River, Prince Co.	Emaciation
8883	Grey	Adult	Female	May	1 km west of Covehead	No Dx
9503	Grey	Immature	Female	Jun	Robinsons Island	Hemorrhagic gastritis
16789	Grey	Immature	Male	Oct	North River	Acute head trauma (hit by boat? clubbed?)
1994						
7950	Harp	Juvenile	Male	May	PEI National Park (Queens Co. North)	Emaciation, acute trauma (intrathoracic hemorrhage)
8639	Grey	Adult	Male	Jun	?	Trauma
8641	Hooded	Immature	Male	Jun	?	Emaciation
11170	Harp	Adult	Female	Jul	Robinsons Island	Emaciation
12035	Grey	7 months	Female	Aug	St. Peters	Emaciation
16299	Harp	Adult	Male	Oct	Rustico Bay	Emaciation, marked gastric parasitism
16974	Hooded	Adult	Male	Oct	Cavendish	Emaciation
17948	Grey	Adult	Female	Nov	Lower Bedeque Bay	No Dx
1995						
10466	Harp	Immature	Male	Dec >94	Kings Co., close to road	Trauma (fell off DFO truck during relocation - euthanized)
20408	Harp	Adult	Male	Oct	Malpeque Bay	No Dx (bilateral intraocular hemorrhage - trauma? drowning?)
22165	Harp	Immature	Female	Nov	Bellevue Cove	Septicemia (*Vibrio* sp.)
22818	Grey	Adult	Male	Nov	Borden	Acute head trauma (shot)
23516	Harp	Immature	Male	Dec	Jacques Cartier Prov. Pk.	No Dx (large internal blood vessels distended with blood - drowning?)
23867	Harp	Immature	Male	Dec	Covehead Harbour	Emaciation
1996						
121	Harp	Immature	Female	Dec >95	Covehead Harbour	No Dx (killed by predators on land?)
1048	Harp	Immature	Female	Jan	Prince Co.	Normal (shot - thought to have been hit by car)
3676	Grey	Immature	Male	Feb	Vernon River	Acute trauma (hit by truck)
3677	Harp	Immature	Male	Feb	Orwell	Emaciation, acute trauma (hit by car)
8978	Grey	Adult, 6 years	Male	May	Chelton	Acute trauma (shot)
22980	Harp	Immature	Female	Dec	Hillsborough River	No Dx (large internal blood vessels distended with blood - drowning?)

Table 2 (continued)

Specimen no	Species	Age	Sex	Month of death	Location	Diagnosis
Brack-1	Harp	Immature	?	Dec	Brackley Beach	No Dx
Back-2	Harp	Immature	Male	Dec	Brackley Beach	No Dx
23752	Harp	Adult	Male	Dec	Tracadie Bay	No Dx (large internal blood vessels distended with blood - drowning?)
23933	Harp	Immature	Female	Dec	Rustico Bay	No Dx (large internal blood vessels distended with blood - drowning? scavenged - killed by predators?)
1997						
907-1	Harp	Immature	Female	Dec >96	Wood Islands	Emaciation, acute trauma (shot)
907-2	Harp	Immature	Male	Dec >96	Wood Islands	Emaciation
2969	Harp	Immature	Male	Jan	Foxley River	Emaciation
3140	Harp	Immature	Male	Jan	New Dominion	Focal subcutaneous trauma (shot) (euthanized)
3957	Harbour	Juvenile	Male	Mar	Montague River	Emaciation, chronic focal (likely parasitic) gastritis with secondary diffuse chronic peritonitis
10090	Grey	Immature	Male	May	Cymbria	Emaciation
10913	Harp	Immature	Female	Jun	Stanley Bridge	Acute enteritis (cause?)
12186	Harbour	Adult	Male	Jun	Meadowbank	No Dx
15832	Harbour	Juvenile	Female	Aug	Cumberland Cove	Severe chronic cellulitis and osteomyelitis (left front flipper), emaciation
20169	Harbour	Juvenile	Male	Oct	Argyle Shore	Emaciation
23877	Harp	Immature	Male	Nov	Tracadie Bay	No Dx (drowning? acute trauma?)
1998						
2537-1	Harbour	Adult	Male	Feb	Pinette Point	Drowning
2537-2	Harbour	Adult	Female	Feb	Pinette Point	Drowning
5632-1	Harbour	?	Male	Jan	West River	Drowning
5632-2	Harbour	?	Male	Feb	West River	Drowning
5632-3	Harbour	?	Male	Mar	West River	Drowning
5632-4	Harbour	?	Male	Apr	West River	Drowning
5632-5	Harbour	Adult	Female	May	West River	Drowning
5632-6	Harbour	Adult	Male	Jun	West River	Drowning
5632-7	Harbour	Adult	Male	Jul	West River	Drowning
6656-1	Harp	Juvenile	Female	Apr	Blooming Point	No Dx (drowning?)
6656-2	Harp	Immature	Male	Apr	Blooming Point	No Dx (drowning?)
6656-3	Harp	Juvenile	Male	Apr	Blooming Point	No Dx (drowning?)
6656-4	Harp	Immature	Male	Apr	Blooming Point	No Dx (drowning?)
6656-5	Harp	Immature	Female	Apr	Blooming Point	No Dx (drowning?)
6761-1	Harp	Immature	Female	Apr	Tracadie	No Dx (drowning?)
6761-2	Harp	Juvenile	Male	Apr	Tracadie	No Dx (drowning?)
6893	Harp	Juvenile	Female	Apr	Dalvay	Septicemia (beta hemolytic *Streptococcus*)
6899	Hooded	Juvenile	Female	Apr	Blooming Point	Emaciation
7640	Harp	Immature	Female	Apr	Tignish	No Dx (drowning?)
7771	Harbour	Adult	Female	Apr	Orwell Bay	No Dx
Hamp-1	Harbour	Immature	Male	Jul	Hampton	Acute trauma (likely boat propeller) (euthanized)
24429	Harp	Immature	Female	Nov	Linkletter	Emaciation
25195	Harp	Immature	Female	Dec	Milton	No Dx
26075	Harp	Immature	Male	Dec	Stanley Bridge	Emaciation

Table 2 (continued)

Specimen no.	Species	Age	Sex	Month of death	Location	Diagnosis
1999						
5787-1	Harbour	Juvenile	Female	Nov >98	Sturgeon River	Drowning
5787-2	Harbour	Juvenile	Female	Nov >98	Sturgeon River	Drowning
5787-3	Harbour	Immature	Male	Nov >98	Sturgeon River	Drowning
5787-4	Harbour	Immature	Female	Nov >98	Sturgeon River	Drowning
5787-5	Harbour	Immature	Female	Nov >98	Sturgeon River	Drowning
5787	Grey	Adult	Female	Jan	Summerside Harbour	Drowning
6429	Harp	Juvenile	Female	Apr	Brackley Beach	Emaciation, peracute septicemia (*E. coli*, *Edwardsiella tarda*) (hospitalized)
10390-1	Harp	Juvenile	?	May or before	Cable Head East	Emaciation
10390-2	Harp	Juvenile	?	May or before	Cable Head East	Emaciation

[a]Animals were considered adult on the basis of their size (standard length and weight), pregnancy status in some females, and distinctive pelage in harp seals. Animals were considered juvenile (<1 year old) on the the basis of their very small size and the presence of lanugo in some harp seals. However, some animals considered immature may also have been juvenile.

[b]Diagnosis

Table 3

Seals necropsied at the Atlantic Veterinary College, 1988 - spring 1999, by species, season, and region.

Species	Number of seals necropsied											
	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov	Prince North	Queens North	Kings North	Kings South	Queens South	Prince South	Unknown	Total
Harbour	9	5	5	2				6	15			21
Grey	2	7	4	4	1	3	1	3	2	5	2	17
Harp	17	14	2	5	5	21	2		7	1	2	38
Hooded	0	1	1	1		2					1	3
Total	28	27	12	12								79

Table 4

Number and percent of survey respondents reporting seal interactions with fishing gear, by survey type, region, and species.

Species		Mail survey							Phone survey							All surveys						
		Prince North	Queens North	Kings North	Kings South	Queens South	Prince South	Total	Prince North	Queens North	Kings North	Kings South	Queens South	Prince South	Total	Prince North	Queens North	Kings North	Kings South	Queens South	Prince South	Total
Lobster traps	No. fishing	49	7	18	52	8	15	149	11	2	2	8		3	26	60	9	20	60	8	18	175
	No. reporting seal interaction	9	0	10	33	5	3	60	3	0	1	3		1	8	12	0	11	36	5	4	68
	% reporting seal interactions	18.4	0.0	55.6	63.5	62.5	20.0	40.3	27.3	0.0	50.0	37.5		33.3	30.8	20.0	0.0	55.0	60.0	62.5	22.2	38.9
Snow crab traps	No. fishing	2			1			3														
	No. reporting seal interaction	1			0			1								2	0	0	1	0	0	3
	% reporting seal interactions	50.0			0.0			33.3								1	0	0	0	0	0	1
																50.0			0.0			33.3
Rock crab traps	No. fishing	4			6	5	4	19														
	No. reporting seal interaction	1			3	3	1	8								4	0	0	6	5	4	19
	% reporting seal interactions	25.0			50.0	60.0	25.0	42.1								1	0	0	3	3	1	8
																25.0			50.0	60.0	25.0	42.1
Flatfish gillnets	No. fishing	5	2		8			15	1	1	0	2			4	6	3	0	10	0	0	19
	No. reporting seal interaction	3	0		6			9	1						1	4	0	0	6	0	0	10
	% reporting seal interactions	60.0	0.0		75.0			60.0	100.0	0.0		0.0			25.0	66.7	0.0		60.0			52.6
Herring gillnets	No. fishing	51	5	8	26	6	13	109	10	2	2	7		2	23	61	7	10	33	6	15	132
	No. reporting seal interaction	42	4	3	14	6	9	78	8	2	0	5		2	17	50	6	3	19	6	11	95
	% reporting seal interactions	82.4	80.0	37.5	53.8	100.0	69.2	71.6	80.0	100.0	0.0	71.4		100.0	73.9	82.0	85.7	30.0	57.6	100.0	73.3	72.0
Mackerel gillnets	No. fishing	47	5	5	18	3	13	91	10	2	2	8		3	25	57	7	7	26	3	16	116
	No. reporting seal interaction	22	2	2	15	1	7	49	7	0	0	4		3	14	29	2	2	19	1	10	63
	% reporting seal interactions	46.8	40.0	40.0	83.3	33.3	53.8	53.8	70.0	0.0	0.0	50.0		100.0	56.0	50.9	28.6	28.6	73.1	33.3	62.5	54.3
Smelt gillnets	No. fishing	23	5	4	10	5	6	53	6	1		1	1	3	12	29	6	4	11	6	9	65
	No. reporting seal interaction	22	4	2	9	4	5	46	6	0		1	1	2	10	28	4	2	10	5	7	56
	% reporting seal interactions	95.7	80.0	50.0	90.0	80.0	83.3	86.8	100.0	0.0		100.0	100.0	66.7	83.3	96.6	66.7	50.0	90.9	83.3	77.8	86.2
Smelt trap-nets	No. fishing	17	2	1	6	8	4	38	5					3	8	22	2	1	6	8	7	46
	No. reporting seal interaction	17	2	0	6	7	4	36	5					2	7	22	2	0	6	7	6	43
	% reporting seal interactions	100.0	100.0	0.0	100.0	87.5	100.0	94.7	100.0					66.7	87.5	100.0	100.0	0.0	100.0	87.5	85.7	93.5
Eel trap-nets	No. fishing	11	4	3	2	2	2	24	5						5	16	4	3	2	2	2	29
	No. reporting seal interaction	3	1	1	1	0	0	6	4						4	7	1	1	1	0	0	10
	% reporting seal interactions	27.3	25.0	33.3	50.0	0.0	0.0	25.0	80.0						80.0	43.8	25.0	33.3	50.0	0.0	0.0	34.5
Silverside trap-nets	No. fishing	7			8	1		16								7	0	0	8	1	0	16
	No. reporting seal interaction	6			8	1		15								6	0	0	8	1	0	15
	% reporting seal interactions	85.7			100.0	100.0		93.8								85.7			100.0	100.0		93.8
Gaspereau gillnets	No. fishing	9	3	3	9	2	2	28								9	3	3	9	2	2	28
	No. reporting seal interaction	3	1	1	4	0	0	9								3	1	1	4	0	0	9
	% reporting seal interactions	33.3	33.3	33.3	44.4	0.0	0.0	32.1								33.3	33.3	33.3	44.4	0.0	0.0	32.1
Gaspereau trap-net	No. fishing	2	2					4														
	No. reporting seal interaction	1	1					2								2	2	0	0	0	0	4
	% reporting seal interactions	50.0	50.0					50.0								1	1	0	0	0	0	2
																50.0	50.0					50.0
Tuna baited hooks	No. fishing	6		1	4			11	5	1	2	4		1	13	11	1	3	8	0	1	24
	No. reporting seal interaction	6		1	4			11	1	0	0	0		0	1	7	0	1	4	0	0	12
	% reporting seal interactions	100.0		100.0	100.0			100.0	20.0	0.0	0.0	0.0		0.0	7.7	63.6	0.0	33.3	50.0		0.0	50.0
Total	No. fishing	233	35	43	150	40	59	560	53	9	8	30	1	15	116	286	44	51	180	41	74	676
	No. reporting seal interaction	136	15	20	103	27	29	330	35	2	1	13	1	10	62	171	17	21	116	28	39	392
	% reporting seal interactions	58.4	42.9	46.5	68.7	67.5	49.2	58.9*	66.0	22.2	12.5	43.3	100.0	66.7	53.4*	59.8	38.6	41.2	64.4	68.3	52.7	58.0

*Percentages do not differ significantly (test of equality of percentages, t_s=1.06, P=0.29; Sokal and Rohlf 1969).

Table 5
Catch loss, gear damage, and expenditures of time and money due to seal interactions with fishing gear

Species and gear		Catch loss per fisher (kg)						Number of gears damaged by seals so they won't fish	Time spent fixing or replacing gear damaged by seals (days)	Money spent fixing or replacing gear damaged by seals
		Due to fish escaping through holes made by seals	Due to seals eating or damaging fish in gear	Due to seals scaring fish out of or away from gear	Due to seals stealing bait or damaging gear so it won't fish	Due to inability to fish in certain areas because of high seal risk	Total			
Lobster traps	No. giving estimates	44	43	36	43	46		45	45	45
	Mean	78.3	40.4	76.9	401	58.7	656	11.7	1.5	140.56
	SD	149	109	185	606	176		18.2	2.8	250.64
	Min	0	0	0	0	0		0	0	0.00
	Max	454	454	907	2,722	907		75	10	1,000.00
	Adjusted mean*	78.3	40.4	74.9	355	58.7	607	11.0	1.5	136.97
Snow crab traps	No. giving estimates	0	0	0	0	0		0	0	0
	Mean						0.0			
	SD									
	Min									
	Max									
	Adjusted mean*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Rock crab traps	No. giving estimates	5	6	5	6	6		5	6	6
	Mean	181	7.6	0.0	847	0.0	1,036	12.0	0.04	83.33
	SD	406	18.5	0.0	1,813	0.0		21.7	0.1	160.21
	Min	0	0	0	0	0		0	0	0.00
	Max	907	45	0	4,536	0		50	0	400.00
	Adjusted mean*	181	7.6	0.0	847	0.0	1,036	12.0	0.04	83.33
Flatfish gillnets	No. giving estimates	5	4	1	3	4		5	7	5
	Mean	454	170	0.0	0.0	0.0	624	5.4	3.4	393.00
	SD	278	217		0.0	0.0		4.7	3.5	635.88
	Min	227	0	0	0	0		1	0	0.00
	Max	907	454	0	0	0		11	10	1,500.00
	Adjusted mean*	454	170	0.0	0.0	0.0	624	5.4	3.4	393.00
Herring gillnets	No. giving estimates	50	46	40	51	53		51	57	55
	Mean	630	506	386	132	601	2,254	3.9	2.4	158.27
	SD	944	613	841	418	3,333		4.2	3.9	302.31
	Min	0	0	0	0	0		0	0	0.00
	Max	5,443	2,722	4,536	2,268	22,680		12	25	2,000.00
	Adjusted mean*	577	480	348	132	601	2,137	3.9	2.2	139.83
Mackerel gillnets	No. giving estimates	35	32	29	34	38		34	39	38
	Mean	501	596	2,578	251	2,032	5,957	2.5	2.1	401.97
	SD	1,210	1,235	10,983	1,181	9,931		4.4	4.0	1,616.54
	Min	0	0	0	0	0		0	0	0.00
	Max	6,804	6,804	58,967	6,804	58,967		22	20	10,000.00
	Adjusted mean*	400	488	1,806	251	2,032	4,976	2.3	1.9	278.02

Table 5 (continued)

Species and gear		Catch loss per fisher (kg)						Number of gears damaged by seals so they won't fish	Time spent fixing or replacing gear damaged by seals (days)	Money spent fixing or replacing gear damaged by seals
		Due to fish escaping through holes made by seals	Due to seals eating or damaging fish in gear	Due to seals scaring fish out of or away from gear	Due to seals stealing bait or damaging gear so it won't fish	Due to inability to fish in certain areas because of high seal risk	Total			
Smelt gillnets	No. giving estimates	43	39	32	42	40		46	45	46
	Mean	588	1,119	1,185	74.5	910.0	3,876	8.5	8.5	191.52
	SD	1,074	1,688	4,072	199	1,818		10.9	16.4	279.40
	Min	0	0	0	0	0		0	0	0.00
	Max	4,536	9,072	22,680	907	9,072		35	72	1,000.00
	Adjusted mean*	541	1,011	931	74.5	848	3,405	8.5	7.5	187
Smelt trap-nets	No. giving estimates	27	25	19	28	27		30	29	29
	Mean	722	1,109	3,170	295	3,284	8,581	3.3	4.6	487.03
	SD	737	1,639	6,885	541	8,055		2.4	4.2	868.37
	Min	0	0	0	0	0		0	0	0.00
	Max	2,268	6,804	27,216	2,268	36,287		10	12	4,000.00
	Adjusted mean*	722	1,044	2,915	288	3,026	7,996	3.3	4.6	443
Eel trap-nets	No. giving estimates	6	5	5	5	4		6	6	6
	Mean	90.7	36.3	54.4	59.0	113	354	4.0	2.5	358.33
	SD	81.1	81.1	98.3	71.0	227		2.5	1.5	568.70
	Min	0	0	0	0	0		0	0	0.00
	Max	227	181	227	181	454		7	4	1,500.00
	Adjusted mean*	90.7	36.3	54.4	59.0	113	354	4.0	2.5	358
Silverside trap-nets	No. giving estimates	11	10	9	7	6		11	11	11
	Mean	6,268	10,750	18,496	648	20,223	56,385	1.0	3.5	809.09
	SD	12,800	15,621	18,268	833	22,502		1.2	3.8	1,188.66
	Min	0	0	227	0	0		0	0	0.00
	Max	36,287	45,359	45,359	1,814	45,359		4	12	4,000.00
	Adjusted mean*	6,268	10,750	18,496	648	20,223	56,385	1.0	3.5	796
Gaspereau gillnets	No. giving estimates	3	3	3	3	3		3	3	3
	Mean	30.2	30.2	30.2	0.0	0.0	90.7	2.7	1.3	166.67
	SD	26.2	26.2	26.2	0.0	0.0		2.9	0.6	57.74
	Min	0	0	0	0	0		1	1	100.00
	Max	45	45	45	0	0		6	2	200.00
	Adjusted mean*	30.2	30.2	30.2	0.0	0.0	90.7	2.7	1.3	167
Gaspereau trap-nets	No. giving estimates	1	1	1	1	1		1	1	1
	Mean	0.0	0.0	454	0.0	0.0	454	0.0	0.0	0.00
	SD									
	Min	0	0	454	0	0		0	0	0.00
	Max	0	0	454	0	0		0	0	0.00
	Adjusted mean*	0.0	0.0	454	0.0	0.0	454	0.0	0.0	0
Tuna baited hooks	No. giving estimates	2	1	0	0	2		1	3	3
	Mean	0.0	0.0			0.0	0.0	0.0	1.2	191.67
	SD	0.0				0.0			0.8	184.28
	Min	0	0	0	0	0		0	1	50.00
	Max	0	0	0	0	0		0	2	400.00
	Adjusted mean*	0.0	0.0			0.0	0.0	0.0	1.2	192

*Based on a truncated data set which excludes values greater than the mean + 2SD of non-zero values

Table 6

Estimated economic cost of seal interactions with fishing gear in Prince Edward Island in 1997

Species and gear	Number of active fishers	Percent of respondents reporting seal-gear interactions	Estimated catch loss in PEI (kg)						Commercial landings in 1997 (kg)[1]	Catch loss due to seals as a percent of commercial landings	Mean price per kg	Value of estimated lost catch[1]	Value of time spent fixing or replacing gear damaged by seals[2]	Money spent fixing or replacing gear damaged by seals	Total cost of seal-gear interactions	Landed value of fishery[3]	Cost of seal-gear interactions as a percent of landed value
			Due to fish escaping through holes made by seals	Due to seals eating or damaging fish in gear	Due to seals scaring fish away from or out of gear	Due to seals stealing bait or damaging gear so it won't fish	Due to inability to fish in certain areas because of high seal risk	Total									
Lobster traps	1307 [4]	38 9	39,790	20,518	39,034	203,871	29,797	333,010	8,095,561	4 1	9 12	3,036,703	78,507	71,383	3,186,593	73,823,076	4 3
Snow crab traps	38 [4]	33 3	0	0	0	0	0	0	1,115,342	0 0	4 86	0	0	0	0	5,419,089	0 0
Rock crab traps	49 [4]	42 1	3,743	156	0	17,469	0	21,368	2,414,592	0 9	0 65	13,801	86	1,719	15,607	1,559,542	1 0
Flatfish gillnets	100 [5]	52 6	23,873	8,952	0	0	0	32,826	231,593	14 2	0 97	31,754	17,669	20,684	70,107	224,031	31 3
Herring gillnets	300 [5]	72 0	135,933	109,325	83,244	28,420	129,717	486,640	15,854,455	3 1	0 18	85,921	51,799	34,173	171,893	2,799,248	6 1
Mackerel gillnets	400 [5]	54 3	108,815	129,486	559,973	54,486	441,351	1,294,112	4,215,092	30 7	0 55	712,285	45,328	87,325	844,939	2,320,005	36 4
Smelt gillnets	80 [5]	86 2	40,542	77,127	81,650	5,136	62,721	267,177	40,439	660 7	1 54	411,270	58,431	13,200	482,902	62,248	775 8
Smelt trap-nets	60 [5]	93 5	40,517	62,228	177,783	16,536	184,209	481,273	120,926	398 0	1 64	787,390	25,626	27,316	840,332	197,842	424 7
Eel trap-nets	55 [6]	34 5	1,721	688	1,032	1,118	2,151	6,710	29,057	23 1	5 71	38,340	4,741	6,796	49,877	166,027	30 0
Silverside trap-nets	20 [5]	93 8	117,522	201,565	346,809	12,150	379,175	1,057,220	237,704	444 8	0 43	457,399	6,563	15,170	479,132	102,841	465 9
Gaspereau gillnet	200 [5]	32 1	1,944	1,944	1,944	0	0	5,832	38,301	15 2	0 32	1,884	8,571	10,714	21,170	12,374	171 1
Gaspereau trap-nets	10 [5]	50 0	0	0	2,268	0	0	2,268	38,228	5 9	0 40	910	0	0	910	15,344	5 9
Tuna baited hooks	140 [5]	50 0	0	0	0	0	0	0	21,944	0 0	17 71	0	8,167	13,417	21,583	388,686	5 6
Total			514,400	611,991	1,293,738	339,187	1,229,121	3,988,437	32,453,234			5,577,658	305,489	301,898	6,185,045	101,618,781	6 1

[1] From DFO statistics files, except eel trap-net data from Lister 1999

[2] Based on a labour cost of $100 per day

[3] From DFO statistics files except eel trap-net data from Lister 1999 Total is for all non-aquaculture fisheries on PEI

[4] From licence base, all licences are active

[5] Estimated by DFO fisheries officers

[6] From a telephone survey (Lister 1999)

Table 7
Estimated number of seals dying due to seal-gear interactions in Prince Edward Island in 1997.

Species and gear	Seal deaths per respondent[1]							Percent of respondents reporting seal-gear interactions	Number of active fishers	Total estimated seal deaths[3]
	N	Sum	Mean	SD	Min	Max	Mean from truncated distribution[2]			
Lobster traps	65	7	0.11	0.40	0	2	0.11	38.9	1307	54.7
Snow crab traps	1	2	2.00		2	2	2.00	33.3	38	25.3
Rock crab traps	8	0	0.00	0.00	0	0	0.00	42.1	49	0.0
Flatfish gillnets	9	10	1.06	1.07	0	3	1.06	52.6	100	55.6
Herring gillnets	93	32	0.34	1.23	0	8	0.34	72.0	300	74.3
Mackerel gillnets	60	22	0.37	1.38	0	10	0.33	54.3	400	79.7
Smelt gillnets	56	16	0.29	1.22	0	8	0.29	86.2	80	19.7
Smelt trap-nets	43	160	3.72	6.85	0	30	3.47	93.5	60	208.7
Eel trap-nets	10	18	1.80	3.05	0	9	1.80	34.5	55	34.1
Silverside trap-nets	13	18	1.38	2.96	0	10	1.38	93.8	20	26.0
Gaspereau gillnet	9	3	0.33	1.00	0	3	0.33	32.1	200	21.4
Gaspereau trap-nets	2	4	2.00	2.83	0	4	2.00	50.0	10	10.0
Tuna baited hooks[4]	12	31	2.58	7.17	0	25	2.58	50.0	140	180.8
Total	381	323								790

[1]Based on respondents who reported seal-gear interactions.

[2]Based on a truncated data set which excludes values greater than the mean + 2SD of non-zero values

[3]Based on the mean from the non-truncated data set

[4]Some of this mortality occurs off the Atlantic coast of Nova Scotia, notably in Chedabucto Bay

Table 8
Measures adopted by fishers in response to seal-gear interactions

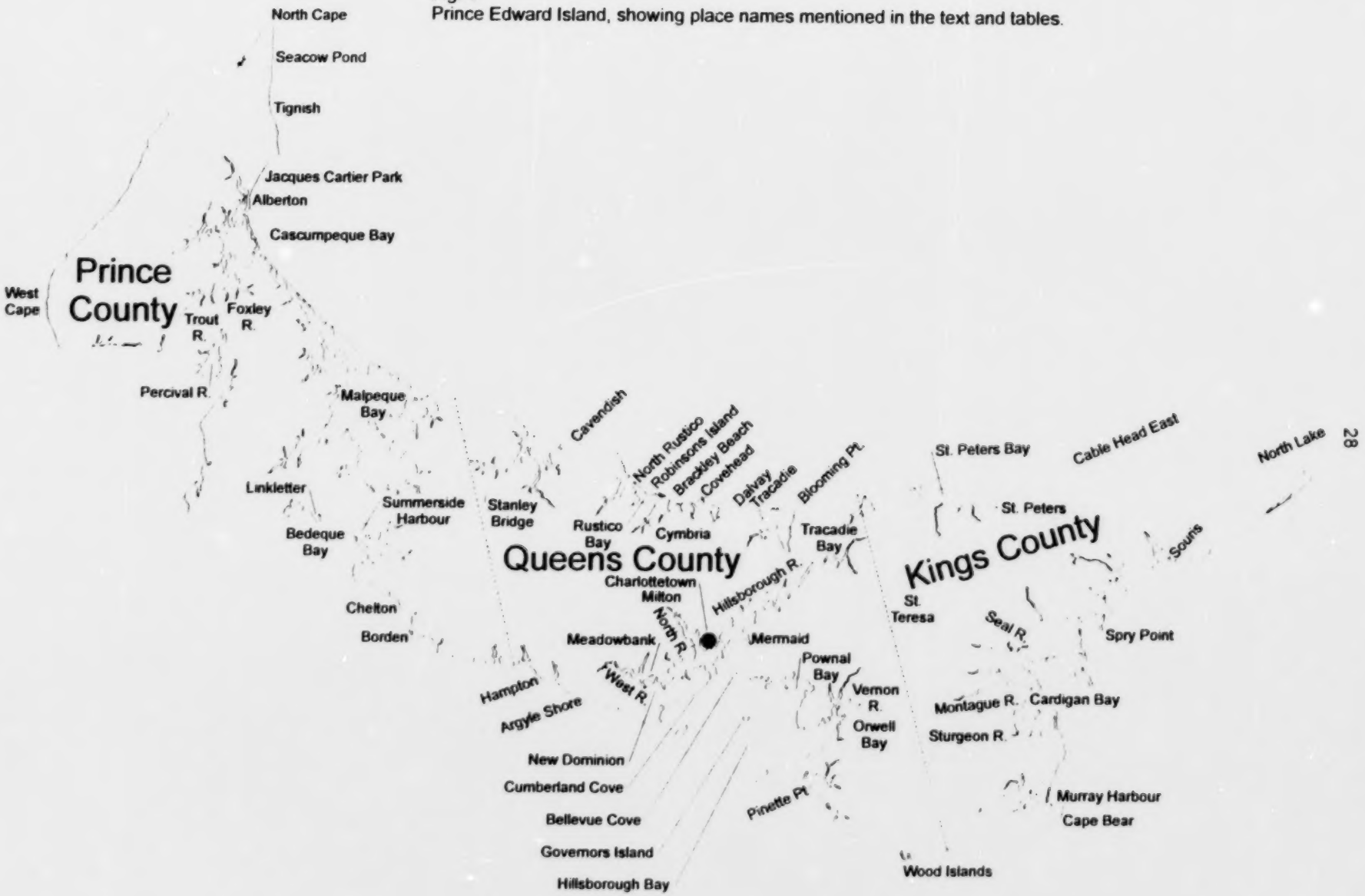
Measure		Lobster traps	Snow crab traps	Rock crab traps	Flatfish gillnets	Herring gillnets	Mackerel gillnets	Smelt gillnets	Smelt trap-nets	Eel trap-nets	Silverside trap-nets	Gaspereau gillnets	Gaspereau trap-nets	Tuna baited hooks
Use bait bag or change method of securing bait	N[1]	13		1										
	Percent[2]	7.4		5.3										
	Total[3]	97		3										
Use smaller entrance rings	N	10												
	Percent	5.7												
	Total	75												
Use steel bait boxes	N	1												
	Percent	0.6												
	Total	7												
Nail laths across entrance rings	N	1												
	Percent	0.6												
	Total	7												
Put coarse mesh nets across trap entrance	N								2					
	Percent								4.3					
	Total								3					
Tie out corners of traps to better maintain shape	N										1			
	Percent										6.3			
	Total										1			
Put top on trap	N										2			
	Percent										12.5			
	Total										3			
Dip gear in tar	N								1					
	Percent								2.2					
	Total								1					
Move gear away from areas frequented by seals	N					1	2	7	5					3
	Percent					0.8	1.7	10.8	10.9					12.5
	Total					2	7	9	7					18
Move gear away from shore or to deeper water	N	2												
	Percent	1.1												
	Total	15												
Move gear closer to shore or upriver	N								4					
	Percent								8.7					
	Total								5					
Stop fishing earlier in season	N							5	4					
	Percent							7.7	8.7					
	Total							6	5					
Fish gear earlier in morning	N								1					
	Percent								2.2					
Stop fishing in non-ice-covered water	N								3					
	Percent								6.5					
	Total								4					
Stop fishing species	N					1		2	2	1				
	Percent					0.8		3.1	4.3	3.4				
	Total					2		2	3	2				

[1]Number reporting this measure
[2]Percent reporting this measure, based on the number of respondents who reported fishing the species/gear
[3]Estimated total number of fishers adopting this measure

Table 9
Biological data on harbour seals taken in smelt trap-nets on Prince Edward Island, January-February 1998. Stomach data are preliminary, and are based on macroscopic examination only.

No.	Date/ location	Sex	Weight/ length	Blubber thickness (mm)	Stomach contents				
					Rainbow smelt	Winter flounder	Tomcod	Nematodes	Other
1	30 Jan Rocky Point, West River	M		Sternal 34	Many	Few	Few	Moderate	
2	30 Jan Rocky Point, West River	M		Sternal 35	Many	Few	Moderate	Moderate	
3	30 Jan Rocky Point, West River,	M		Sternal 37	Moderate	Few	Few	Moderate	
4	30 Jan Rocky Point, West River	M		Sternal 35	Many		Few	Moderate	
5	30 Jan Rocky Point, West River	F	101 kg 156 cm	Sternal 40 Dorsal 40	Many	Moderate	Moderate	Moderate	Unidentified eel-like fish
6	30 Jan Rocky Point, West River	M	79.5 kg 159 cm	Sternal 31 Dorsal 38	Few	Few	Few	Moderate	
7	30 Jan Rocky Point, West River	M	97 kg 160 cm	Sternal 40 Dorsal 39	Many	Moderate	Few	Moderate	
8	5 Feb MacAulay's Wharf, Pinette River	M	96.5 kg 155 cm	Sternal 43 Dorsal 39	Many	Many	Moderate	Moderate	
9	10 Feb MacAulay's Wharf, Pinette River	F	84 kg 143 cm	Sternal 39 Dorsal 39	Few	Few	Few	Few	
10	18 Feb MacAulay's Wharf, Pinette River	M	95 kg 154 cm	Sternal 34 Dorsal 34	Many	Few	Few	Moderate	
11	18 Feb MacAulay's Wharf, Pinette River	F	115.4 kg 163 cm	Sternal 49 Dorsal 48	Many	Many	Moderate	Moderate	

Fig. 1
Prince Edward Island, showing place names mentioned in the text and tables.



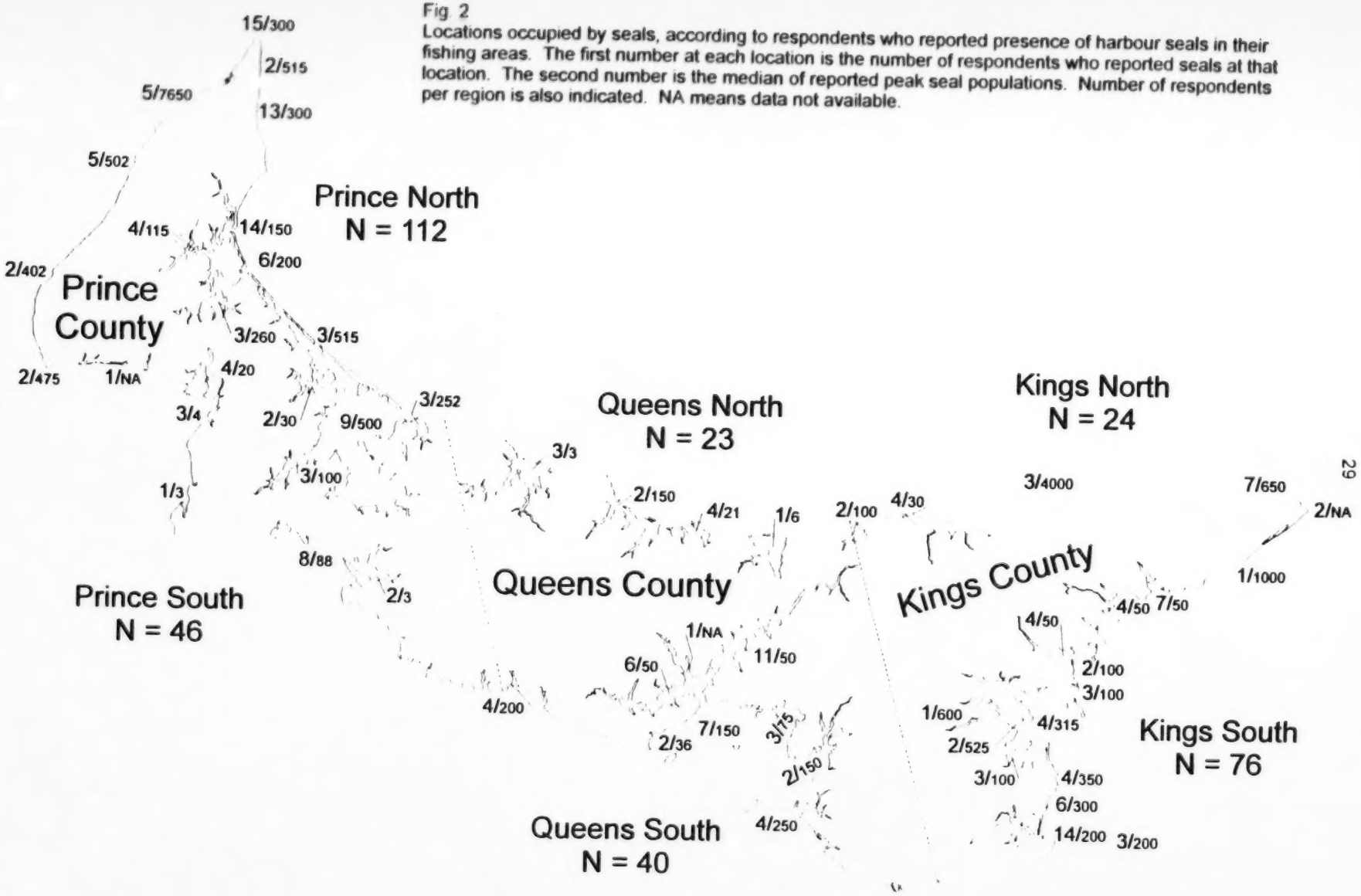


Fig. 2
Locations occupied by seals, according to respondents who reported presence of harbour seals in their fishing areas. The first number at each location is the number of respondents who reported seals at that location. The second number is the median of reported peak seal populations. Number of respondents per region is also indicated. NA means data not available.

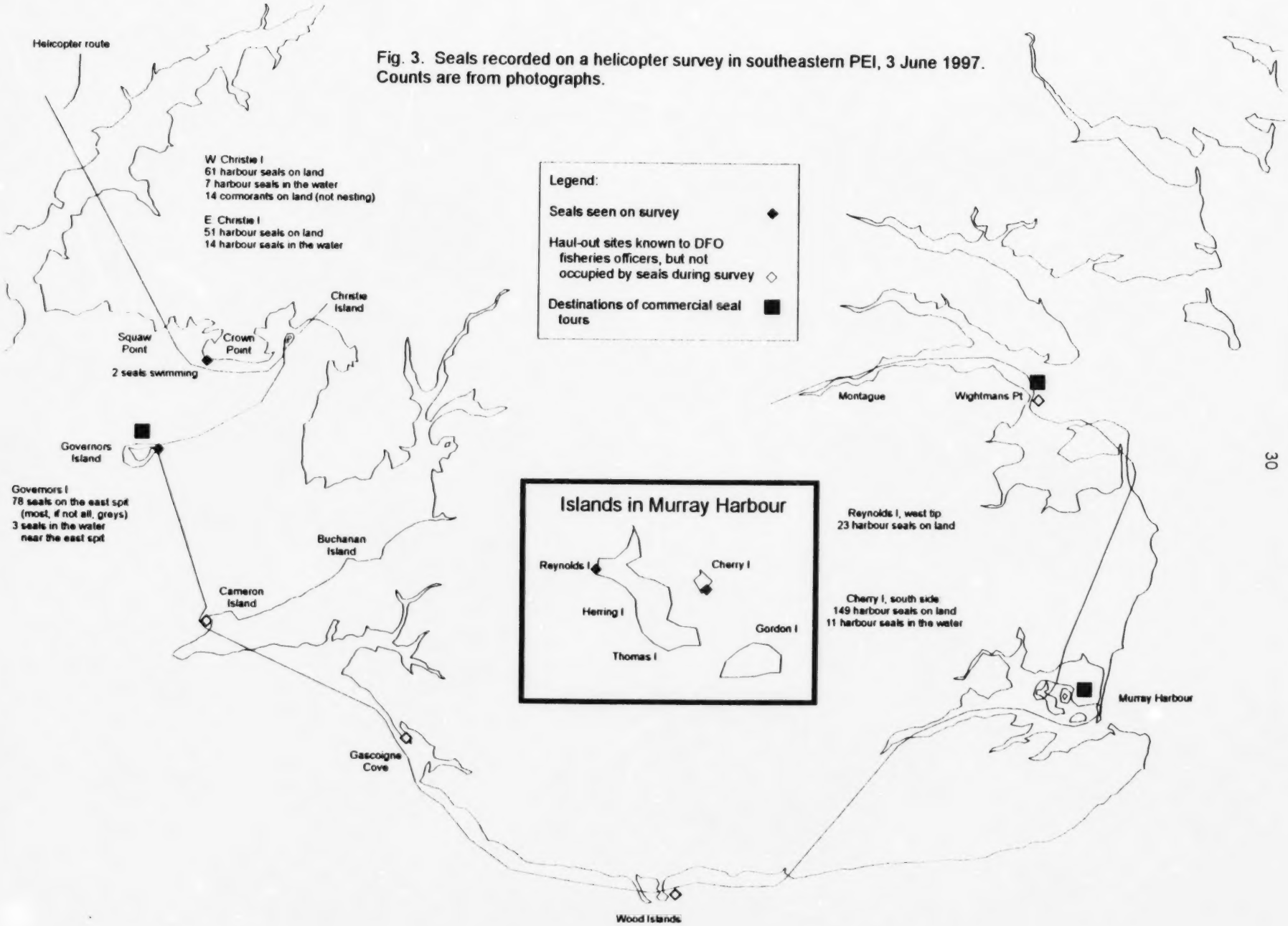
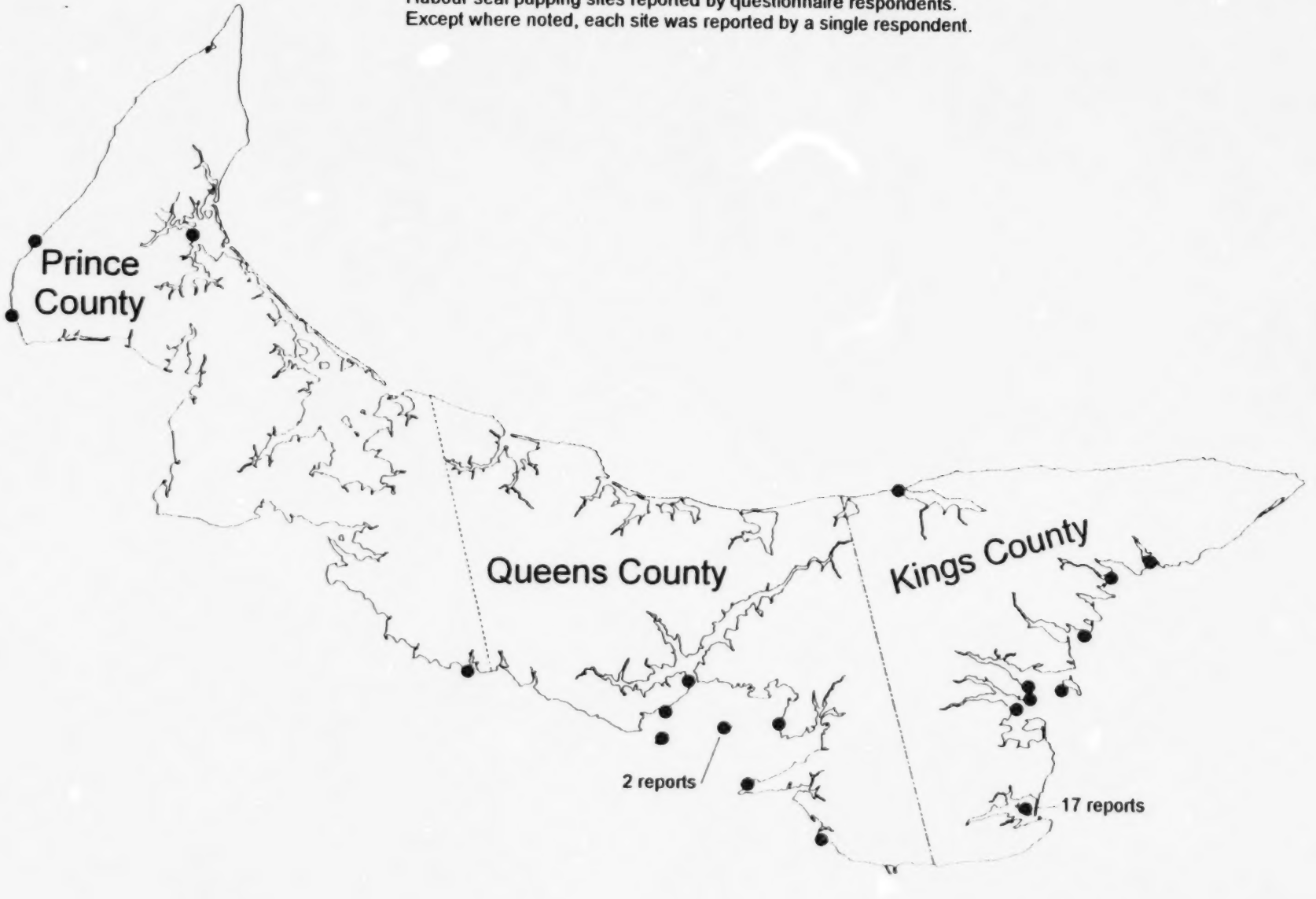


Fig. 3. Seals recorded on a helicopter survey in southeastern PEI, 3 June 1997. Counts are from photographs.

Fig. 4
Habour seal pupping sites reported by questionnaire respondents.
Except where noted, each site was reported by a single respondent.



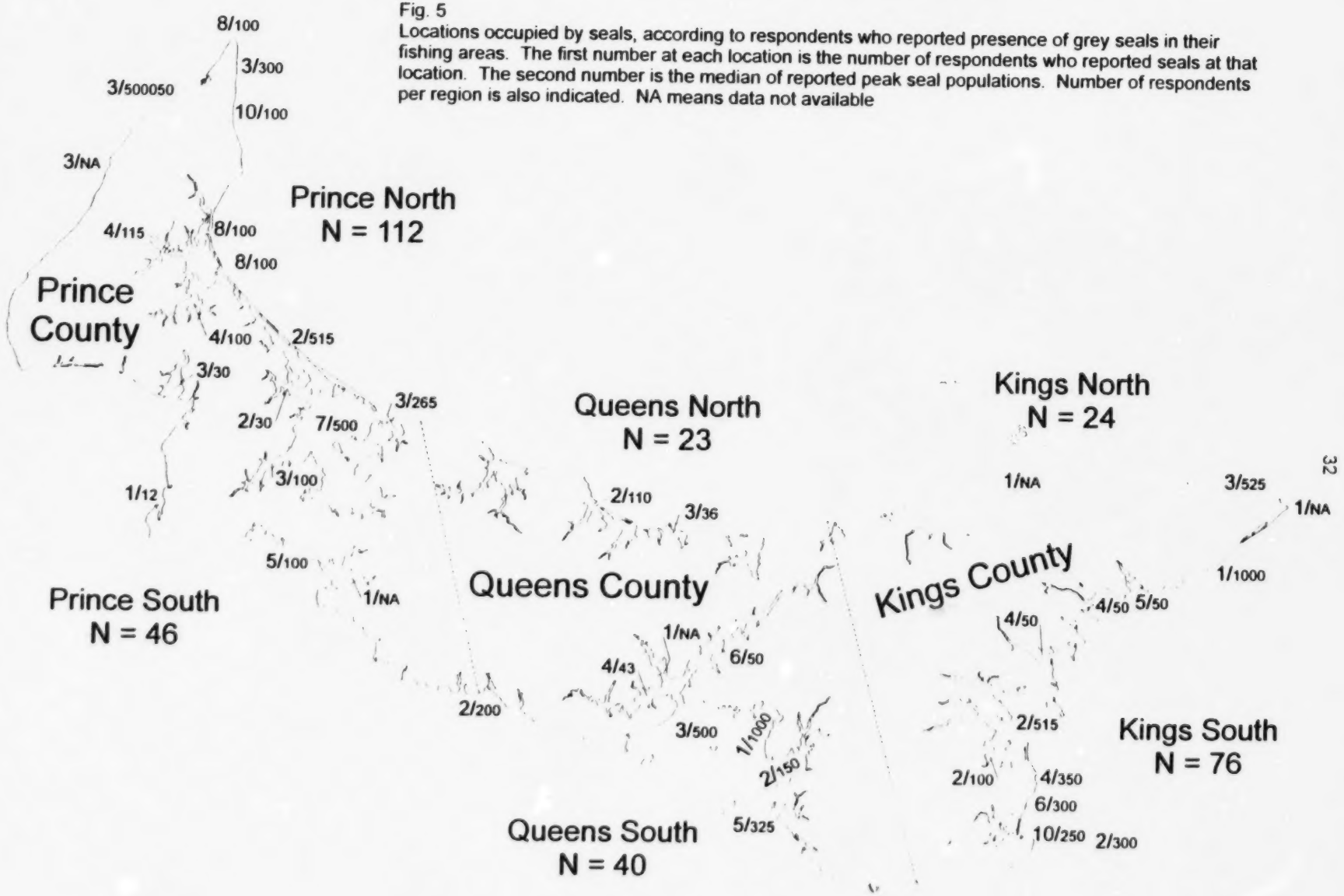


Fig. 5
Locations occupied by seals, according to respondents who reported presence of grey seals in their fishing areas. The first number at each location is the number of respondents who reported seals at that location. The second number is the median of reported peak seal populations. Number of respondents per region is also indicated. NA means data not available

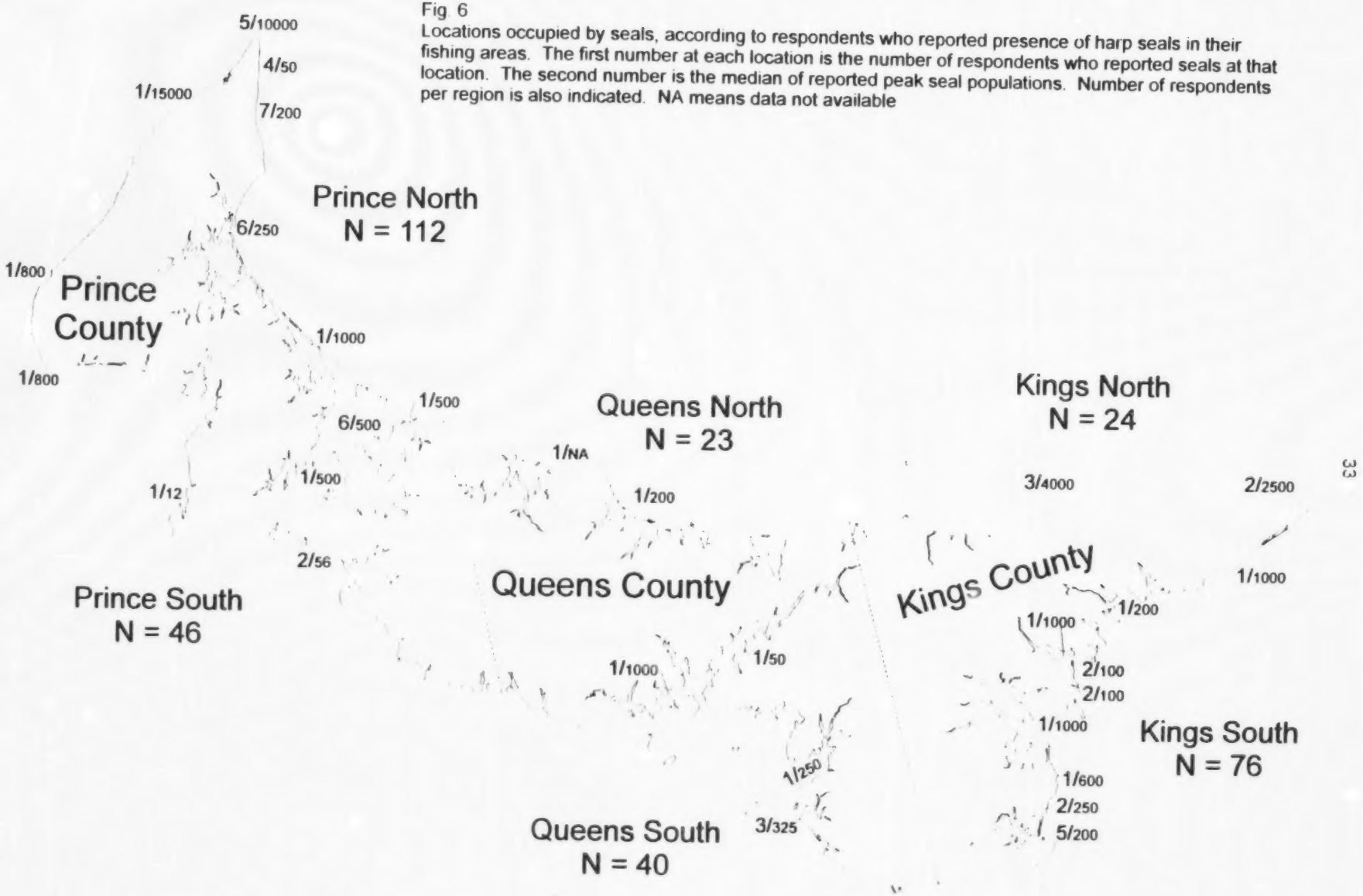
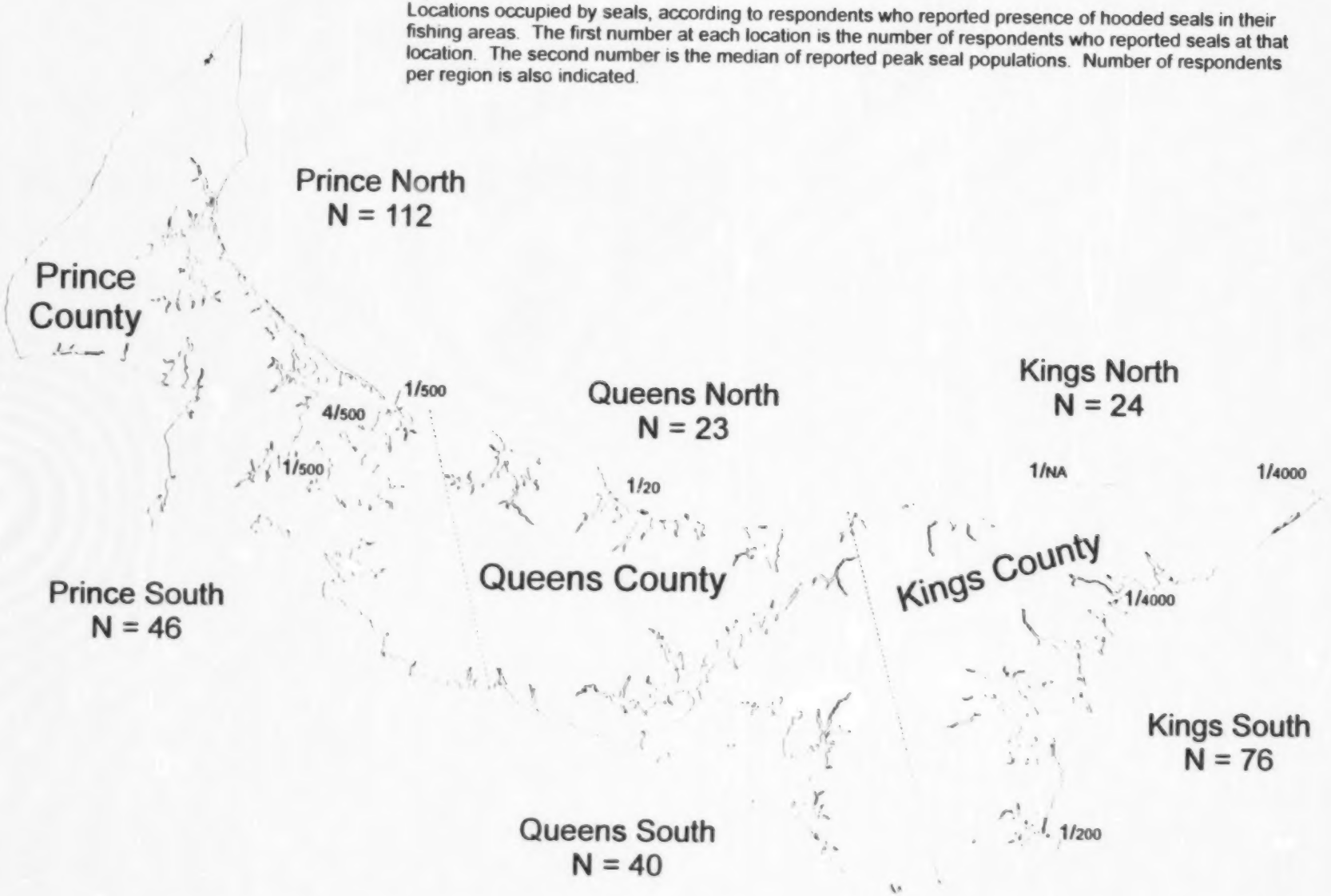


Fig. 6
Locations occupied by seals, according to respondents who reported presence of harp seals in their fishing areas. The first number at each location is the number of respondents who reported seals at that location. The second number is the median of reported peak seal populations. Number of respondents per region is also indicated. NA means data not available

Fig. 7
Locations occupied by seals, according to respondents who reported presence of hooded seals in their fishing areas. The first number at each location is the number of respondents who reported seals at that location. The second number is the median of reported peak seal populations. Number of respondents per region is also indicated.



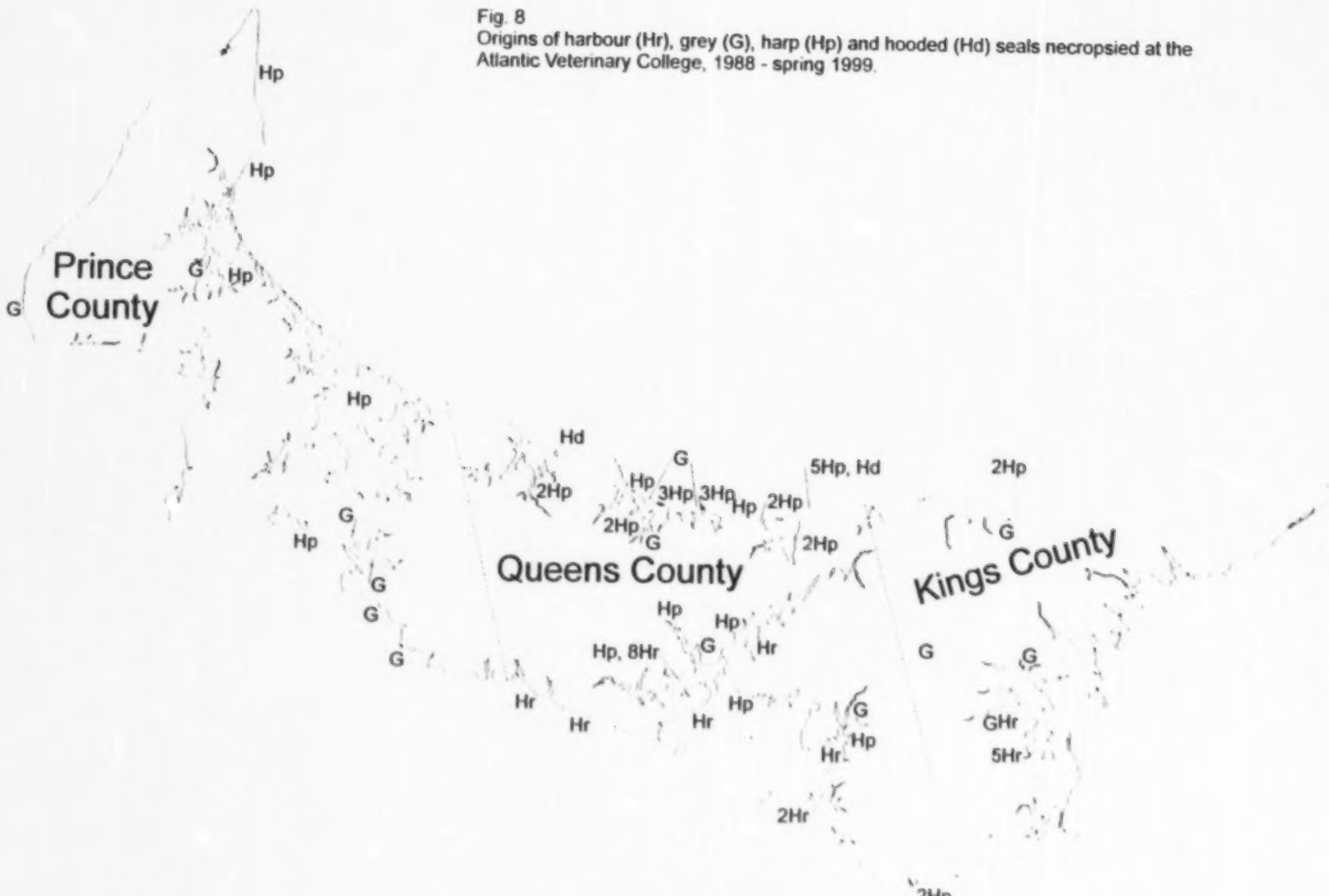


Fig. 8
Origins of harbour (Hr), grey (G), harp (Hp) and hooded (Hd) seals necropsied at the Atlantic Veterinary College, 1988 - spring 1999.

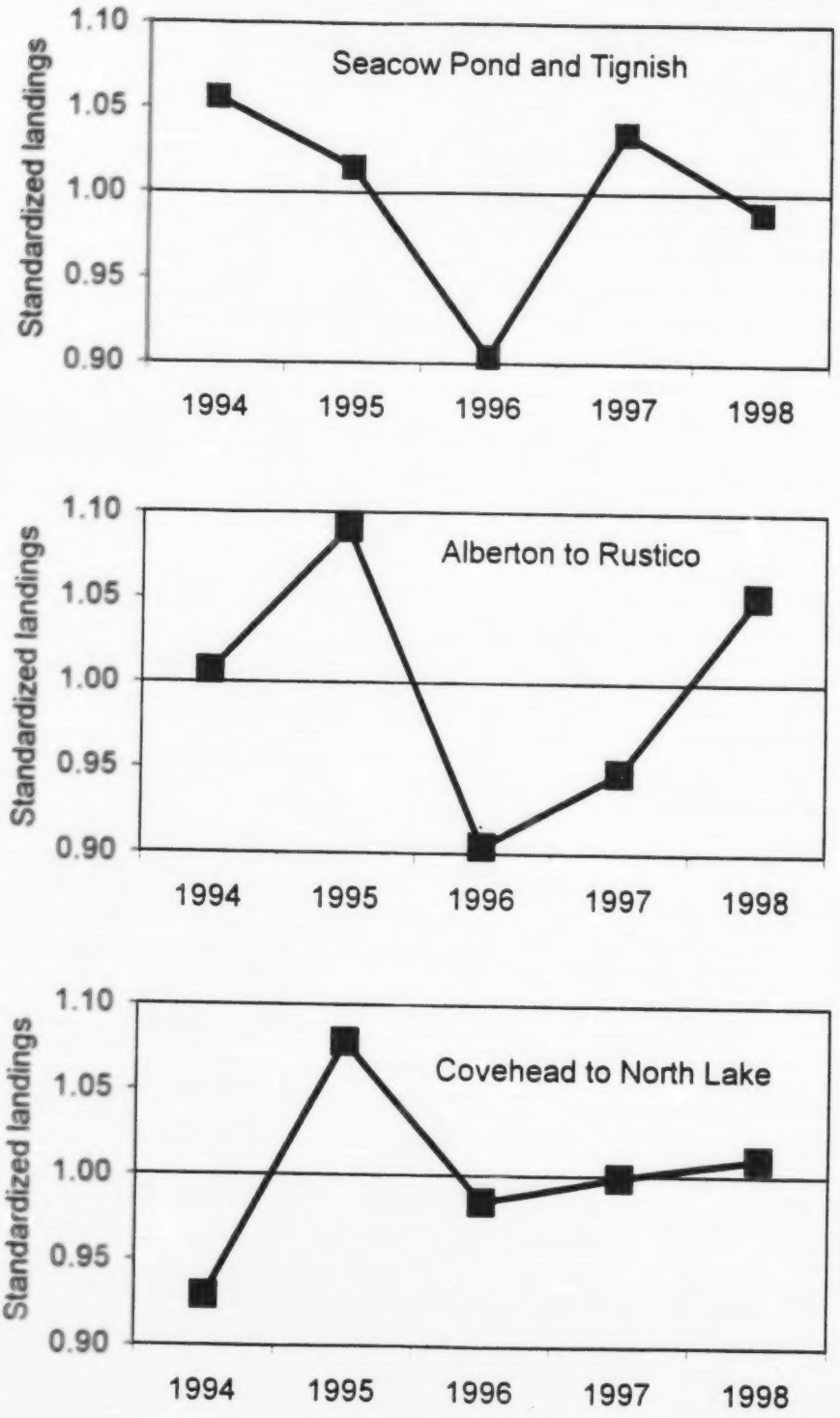


Fig. 9
Lobster landings on the North Shore of Prince Edward Island, 1994-1998.
Landings are standardized by dividing yearly landings by the five-year mean.

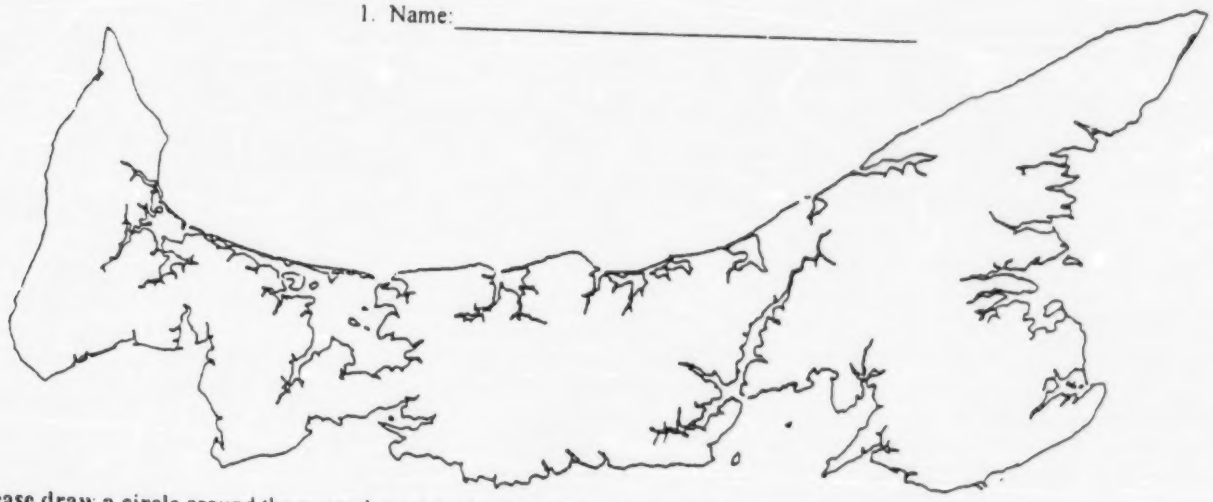
Appendix A. Questionnaire sent to commercial fishers on Prince Edward Island.

SEAL / FISHERIES SURVEY

THE P.E.I. FISHERMEN'S ASSOCIATION WANTS TO HAVE A BETTER UNDERSTANDING OF SEAL ISSUES ON PRINCE EDWARD ISLAND. YOU CAN HELP BY ANSWERING THE FOLLOWING QUESTIONNAIRE AND RETURNING IT IN THE ENCLOSED ENVELOPE WITHIN ONE WEEK.

FOR MORE INFORMATION, CALL DELLY KEEN, PROJECT COORDINATOR, AT 566-4050.

1. Name:_____



2. **Please draw a circle** around the general area(s) where you fish. **Mark** an "X" at places where you regularly see seals Harbour pups have their seals in May and June. **Mark** a "P" if you know of places where harbour seals have their pups.

3. Please circle the months when you see seals in the area(s) where you fish:

January February March April May June July August September October November December

4. How many seals do you think are in your area during their period of peak numbers?_____

5. Are seal populations in your area: decreasing_____, staying about the same_____, or increasing_____?

6. Please add any comments on seal populations in your area. We are particularly interested in knowing what species of seals you are seeing, and how their numbers are changing. The pictures overleaf show the different kinds of seals found in our waters.

_____

_____

_____

_____

_____

This study is sponsored by the PEI Fishermen's Association in collaboration with the PEI Department of Fisheries and the Environment, DFO Science Branch and the Atlantic Veterinary College

Return Questionnaire to
Seal Survey
Box 2000 Charlottetown
PEI C1A 7N8

This Questionnaire is confidential once completed

7. Please tell us the fishing gear you used in 1997, and your losses due to seals. For smelts, please use the fall 1996/winter 1997 fishing season.
(See example at the bottom of this page)

Species & Gear		Check if you fished with this gear in 1997	Check if seals interacted with your gear in 1997	If seals interfered with your gear in 1997, please tell us about it below.								
				Catch loss (pounds) because fish escaped through holes made by seals	Catch loss (pounds) because seals ate or damaged fish in gear	Catch loss (pounds) because seals scared fish out of gear or away from gear	Catch loss (pounds) because seals stole bait or damaged gear so it wouldn't fish	Catch loss (pounds) because you can't fish in certain areas because of high seal risk	Number of traps/nets damaged by seals so that they wouldn't fish	Time that you spent (days) fixing gear damaged by seals	Money you spent fixing or replacing gear damaged by seals	Number of seals raiding your gear that died (drowning, other causes)
Lobster	Trap											
Flounder -Dabs	Gillnet											
Blackbacks	Gillnet											
Herring	Gillnet											
Mackerel	Gillnet											
Rock Crab	Trap											
Snow Crab	Trap											
Toad Crab	Trap											
Smelt	Gillnet											
	Trapnet											
Eels	Trapnet											
Silversides	Trap											
Gaspereaux	Gillnet											
	Trapnet											
Other (Specify)												

Example. Species A: Fished with gillnets in 1997. No interference by seals.
Species B: Fished with gillnets, no interference by seals. Fished with trapnets, seals made holes in 3 trapnets, allowing about 400 pounds to escape. Each trapnet took 1 day of your time to fix and replacement netting for the traps cost $250. You lost about 600 pounds of catch during the time your gear wasn't fishing.

Species A	Gillnet	✓										
Species B	Gillnet	✓										
	Trapnet	✓	✓	400	-	-	600	-	3	3	250	-

Please provide any comments you feel are important overleaf.

8. If seals cause damage or loss to your fishing activity, please tell us how?

9. Have you made any changes to your gear or fishing practices to reduce losses due to seals? Yes _____ No_____

Please Describe:

10. How well have these changes worked?

11. Use this section for any additional comments you have on seals, and for your suggestions for new ways to deal with seal-gear problems.